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Microhabitat Comparison of *Percina roanoka* (Roanoke Darter) and *P. nevisense* (Chainback Darter) in the Roanoke River

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ABSTRACT

Snorkel observations of *Percina roanoka* and *P. nevisense* in the Roanoke River during summer months were followed by measuring current velocity, water depth, and substrate diameter at points of occupation. A total of 89 observations of *P. roanoka* and 81 observations of *P. nevisense* were compared using two-sample T-tests. *Percina roanoka* inhabited faster, shallower water than *P. nevisense* with the former found in a mean flow of 0.318 m/s and depth of 31.53 cm and the latter in a mean flow of 0.17 m/s and depth of 55.6 cm. Mean diameter of substrate at points of occupation did not differ significantly between the two species with *P. roanoka* over substrate 10.14 cm diameter, and *P. nevisense* over substrate of 9.7 cm diameter. Differences in habitat among age classes were not detected for either species. These findings suggest habitat partitioning along current velocity and depth help maintain the diverse darter assemblage in the Roanoke River.

INTRODUCTION

Resource partitioning appears to be a key component of maintaining diverse fish assemblages, with habitat and food partitioning cited as especially important in communities containing members of the same family (Ross 1986). Six species of Percidae are native to the Roanoke River upstream of the Blue Ridge (Jenkins and Burkhead 1994). Comparisons of habitat parameters have long suggested habitat partitioning among these species is likely key to their survival in the Roanoke River (Matthews et al. 1982; Matthews 1985; Matthews 1990). However, these early studies were based either on captive observation or collections using seines followed by measuring stream width, gradient, and maximum current velocity within the sampled area. As habitat parameters are rarely uniform within the seined area, a reality discussed in these papers, the data collected are not precise measurements of occupied habitat. Recent studies have described and compared habitat of some darter species based on specimens captured using seines and/or a backpack electrofisher. Following capture, habitat parameters from multiple points within a sampled area were measured within that area and averaged making less precise descriptions of occupied habitat (Vadas and Orth

2000; Roberts and Angermeier 2007). Rosenberger and Angermeier (2003) used snorkel transects to identify microhabitat among age classes of *Percina rex* (Roanoke Logperch) but did not compare these data to other darter microhabitat data. Another recent snorkeling study measured microhabitat of *Percina nevisense* (Chainback Darter) and found they only occupy a portion of available habitat in the Roanoke River but did not compare it to microhabitat data of other darter species (Powers and Whitlow 2018). Collectively, these studies suggest darters have fidelity to specific microhabitats and do partition habitats. However, those studies do not directly compare specific microhabitats of sympatric darters in the Roanoke River. The objective of this study was to test for habitat partitioning among the closely related *Percina roanoka* (Roanoke Darter) and *P. nevisense* using snorkel observation data from precise points of occupation during summer months in the Roanoke River.

MATERIALS AND METHODS

Snorkeling observations were made during summer 2016-2018 in the Roanoke River in Salem, Virginia. At this locality, the river is a fifth order stream, approximately 30m wide with a maximum depth of 1.5 m at base flow. A 5 cm diameter galvanized steel marker numbered and painted fluorescent green was placed at the point of first sighting of an individual of each target species to mark the exact point of observation. Species, number observed, and approximate age class (i.e. juvenile, subadult, adult) were recorded on a diver's underwater writing slate immediately following the placement of each marker. Age classes were determined by estimation of standard length (SL). For *Percina roanoka,* juveniles were less than 25 mm SL, subadults 25-45 mm SL, and adults greater than 45 mm SL. *Percina nevisense* age class estimation followed Powers and Whitlow (2018). Upon completion of snorkel observations each day, we returned to each marker and measured water depth and diameter of five representative rocks within 10 cm of the marker with a meter stick. Current velocity approximately 5 cm above the substrate was also measured with a FloWatch flowmeter. Data for each species were summarized and compared with two-sample T tests. A one-way analysis of variance was used to detect differences in mean values between juveniles, subadults, and adults. Minitab 18 was used to generate 95% confidence interval plots (Figures 1-3) and for all statistical analyses with alpha = 0.05.

RESULTS

Data were collected from a total of 81 observations of *Percina nevisense* from 8 days of observation from June and July, and 89 observations of *P. roanoka* from 9 days of observation from June and July. Age classes of *P. roanoka* (5 juveniles, 11 subadults, 73 adults) were not different for depth, current velocity, or substrate (P = 0.55, 0.28, 0.82, respectively), and Powers and Whitlow (2018) similarly found no differences in habitat among age classes for *P. nevisense*. *Percina nevisense* occupied depths ranging from 36 to 97 cm (mean = 55.6 cm, SD = 12.3), current velocities ranging from 0 to 0.4 m/s (mean = 0.17 m/s, SD = 0.094), and substrate diameter ranging from less than 1 to greater than 100 cm (mean = 9.7 cm, SD = 13). *Percina roanoka* occupied depth ranging from 19 to 48 cm (mean = 31.53 cm, SD = 7.93), current velocities ranging from 0 to 0.6 m/s (mean = of 0.318 m/s, SD = 0.114), and substrate diameters ranging from less than 1 to 42 cm (mean = 10.14 cm , SD = 7.74). The two species differed significantly (P <0.001)

in depth and current velocity but not substrate diameter (P = 0.59). Mean values and 95% confidence interval plots are presented in Figures 1-3.

DISCUSSION

Powers and Whitlow (2018) found no differences among age classes of *Percina nevisense* for any measured variable. Similarly, we found no differences among age classes of *P. roanoka* for any variable measured. In contrast, habitat partitioning among age classes was found in *P. rex* (Rosenberger and Angermeier 2003). Vadas and Orth (2000) described the microhabitat of *P. roanoka* as 26 to 75 cm/s current velocity over substrate ranging from 6.5 to 16 cm in diameter, but as discussed earlier, their methods did not record habitat at exact points of occupancy. Our mean substrate diameter is largely consistent with the substrate size yielding the greatest number of *P. roanoka* in previous studies (Mathews et al. 1982; Vadas and Orth 2000). While our current velocity data appear similar to that reported by Vadas and Orth (2000), we did find both minimum and maximum current velocity inhabited by *P. roanoka* to be slower. Our data also show much lower current velocities than the riffle habitat (0.79 m/s) reported by Matthews et al. (1982) to have the greatest abundance of *P. roanoka*. The mean current velocity of our study almost perfectly matches the critical current speed (0.3 m/s) for *P. roanoka* in a flow chamber reported by Matthews (1985). This suggests the actual microhabitat occupied by the species is likely different than what has been reported in previous studies and closely matches that for which they are morphologically adapted. Given this finding, it appears snorkeling observation followed by measuring habitat parameters at exact points of observation is more likely to identify accurate habitat parameters than capturing specimens by seine and measuring those same parameters throughout the sampled area. Stauffer et al. (1996) similarly found underwater observation to be most effective at detecting these fine scale differences among microhabitats.

Powers and Whitlow (2018) reported mean values for *P. nevisense* habitat data from throughout the year to be 60.5 cm depth, 0.17 m/s current velocity, and 8.2 cm substrate diameter, but also noted differences among seasons. The mean values for summer months incorporated into this study closely match the mean microhabitat values throughout the year. Direct comparison of data from June and July showed *P. roanoka* occupied shallower ($P < 0.001$) and faster ($P < 0.001$) water than *P. nevisense.* Substrate diameter does not appear to differ between species (P = 0.585). The difference in current velocity between these species appears similar to the faster current inhabited by *P. roanoka* compared to *Etheostoma flabellare* (Matthews et al. 1982; Matthews 1985). Matthews et al. (1982) suggested habitat partitioning between *P. roanoka* and *E. flabellare* based on current velocity and stream size with *E. flabellare* inhabiting smaller streams than *P. roanoka*. While *P. nevisense* and *E. flabellare* both inhabit slower water than *P. roanoka,* it appears unlikely these species are competing for habitat in these slower waters of the same streams. The greatest abundance of *E. flabellare* reported by Matthews et al. (1982) occurred in second order streams less than 2 m in width. During data collection for this study, relatively few *E. flabellare* were observed. The mainstem Roanoke River in Salem is a fifth order stream approximately 30 m in width and has little similarity to the second order streams reported as ideal habitat by Matthews et al. (1982). This suggests that just as *P. roanoka* and *E. flabellare* partition habitat partly along

stream size, so do *P. nevisense* and *E. flabellare.* Partitioning among *P. nevisense* and *E. flabellare* is likely stronger than the partitioning among *P. roanoka* and *E. flabellare* as *P. nevisense* and *E. flabellare* occupy similarly slower water than *P. roanoka.*

Our finding of habitat partitioning among *Percina* in the Roanoke River is similar to the findings of other studies with different species of *Percina* inhabiting different depths, current velocities, and/or substrate sizes. Welsh and Perry (1998) found *P. caprodes* in faster current over finer substrates than *P. macrocephala* in the Elk River, West Virginia. Stauffer et al. (1996) also noted low niche-breadth values for *P. caprodes* and *P. copelandi* in the Allegheny River system with the latter found mostly in faster current than the former. Habitat partitioning among species of *Percina* utilizing different depths and current velocities has also been documented in tributaries to the Tennessee and Alabama river systems (Weiland 1983; Greenberg 1991). Our findings further suggest habitat partitioning among closely related species is likely important to maintaining diverse fish assemblages, and precise measurements of occupied microhabitat help elucidate fine scale differences among them.

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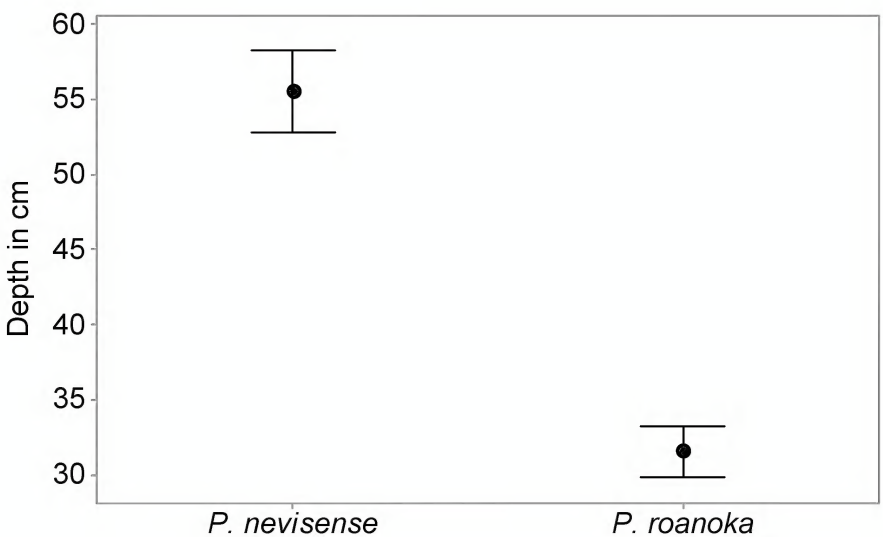

Figure 1: Interval plot showing 95% confidence of mean depth of water occupied by *Percina nevisense* and *P. roanoka* in the Roanoke River.

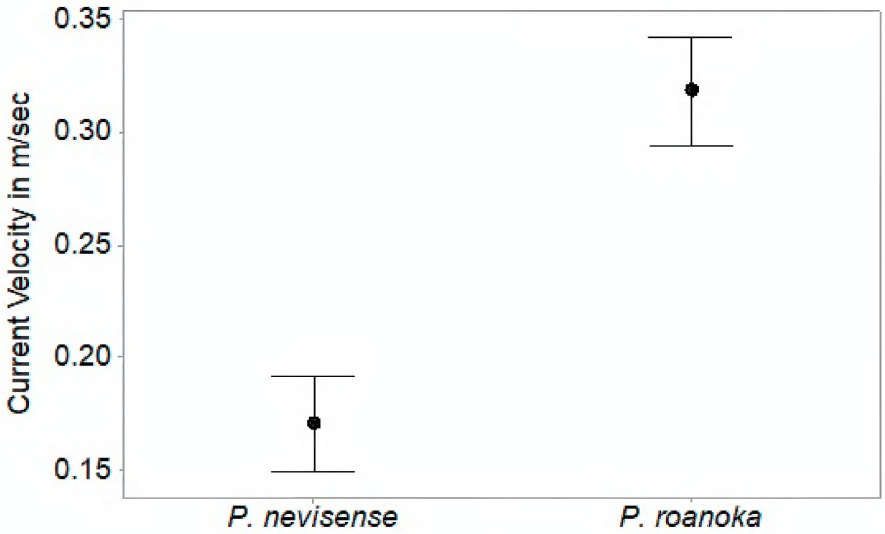

Figure 2: Interval plot showing 95% confidence of mean current velocity occupied by *Percina nevisense* and *P. roanoka* in the Roanoke River.

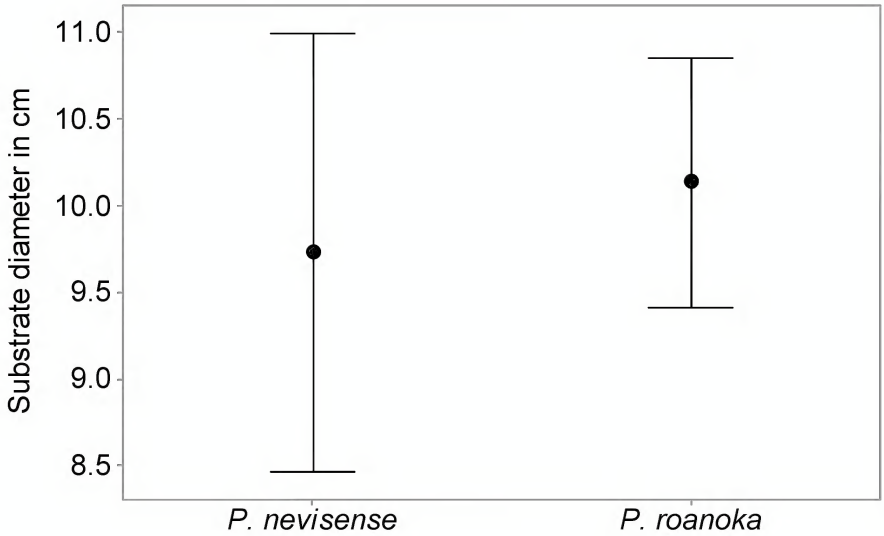

Figure 3: Interval plot showing 95% confidence of mean substrate diameter at points of observation for *Percina nevisense* and *P. roanoka* in the Roanoke River.

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Pollinator Visitation Frequency Associated with Native and Non-native Plants in a Mid-Atlantic Piedmont (USA) Urban Garden

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ABSTRACT

The recent focus on the importance of native plants and their pollinators has highlighted the critical role of local species in their natural environment. As urban encroachment, climate change, and invasive species continues to threaten native habitats, it is increasingly important to promote the use of local green spaces as refugia for native plants and their pollinators. The aim of this project, therefore, was to identify and assess the visitation frequency of insect pollinators associated with an urban setting within the Piedmont region of Virginia, and compare their association with native versus closely-related but non-native summer-flowering plants. Several modes of insect examination were used to assess these metrics in the Brian Wesley Moores Native Plant Garden on the campus of Randolph-Macon College. We observed an overall preference for the native species on a total of four native:non-native pair comparisons, including a higher number of total insect visitors and a more diverse assortment of pollinator types. Our data supports the notion that native plant species should be prioritized in urban green spaces, as it provides the appropriate flora to support ecosystem balance in a setting threatened by human activities.

Keywords: native plants, non-native plants, pollination, urban garden

INTRODUCTION

Healthy native ecosystems are well known for their ability to provide such fundamental services as the production of consumable resources, the mitigation of climactic fluctuations, and the amelioration of anthropogenic environmental degradation (Daily et al., 1997; Tilman, 1997). In urban areas, they are also known to promote human health and well-being, in part through cultivation of a positive aesthetic (Pejchar

and Mooney, 2009). Invasion of natural areas by non-native species can significantly hinder the provision of all of these benefits (Pimental, 1986; Vitousek et al., 1997). For example, plant pollination – both natural and managed – is a key ecosystem process that depends largely on the partnership between a plant and its pollinator(s) (Kearns and Inouye, 1997; Kearns et al., 1998). Effective pollination is critical to human health and agriculture, as over 80 percent of the plants grown for consumption and medicinal use rely on pollinators for reproduction and fruiting (Daily et al., 1997). Insects, in particular, are important pollinators, and at least one in every third bite of food in the American diet is courtesy of insect pollination (Klein et al., 2007; Potts et al., 2010). Over time, native plants and their pollinators have evolved a fragile co-dependence such that the loss of either member of the partnership (through pesticide use, disease, or the introduction of non-native species) can drastically reduce the survival of both (Kearns et al., 1998; Spira, 2001).

Until recently, imported European honeybees (*Apis mellifera*) have been managed as a pollination vector for many human agricultural crops. However, the onset of Colony Collapse Disorder – in which formerly healthy honeybee colonies have experienced a sudden, unexplained loss of adult workers – and subsequent financial losses to industrial agriculture has spurred research into the role and status of native insect pollinators. So far, results demonstrate that native pollinators – bees, in particular – are more than able to "pick up the slack" left by declining honeybee populations, in some cases demonstrating double the efficiency of non-native honeybees (Winfree et al., 2007; Garibaldi et al., 2013). Unfortunately, native pollinator populations are also in decline, in part as a result of habitat fragmentation (Garibaldi et al., 2013). Ongoing research supports urban agriculture and gardening as a way of providing "oases" for these native pollinators (Hennig and Ghazoul, 2012; Baldock et al., 2015) and has found that, in some cases, urban green spaces can support a diversity of insect pollinators that is concomitant with more rural, natural areas (Hennig and Ghazoul, 2012). In many cases, the targeted use of native plants in these spaces has been shown to more strongly promote overall biodiversity and ecosystem health, especially for insect pollinators co-adapted to take advantage of native resources (Frankie et al., 2002; Hanley et al., 2014).

It was the aim of this study to identify local insect pollinators and compare visitation frequency to common horticultural native and non-native summer-flowering perennials in an Ashland, VA, urban plant garden. Because of the strong co-dependence in plant/pollinator relationships, we expected native plants to play a more substantive role in pollination activity by drawing the highest abundance of local pollinators.

METHODOLOGY

Study site

Our study was conducted at the Brian Wesley Moores Native Plant Garden, located on the Randolph-Macon College campus in Ashland, VA (37°45'58.4" N 77°28"35.8" W). The garden comprises a 0.19-acre plot situated at the northeastern gateway to the college and is adjacent to a residential neighborhood (Figure 1). This area is part of the Piedmont Region of the Mid-Atlantic United States and is characterized by

an acidic clay loam soil and a hardiness zone of 7a – 8 (USDA). Historically, the majority of the land in this area has seen heavy agricultural use (USDA).

Plant species

We used four locally native/non-native pairs of summer-flowering perennials that are commonly included in local gardens and managed landscapes. All species (locally-native and non-native) have a demonstrated record of attracting a wide range of pollinators (Lowenstein et al., 2015; Rowe et al., 2018). Locally-native species included: *Echinacea purpurea* (purple coneflower), *Liatris spicata* (blazing star), *Asclepias tuberosa* (butterflyweed), and *Monarda fistulosa* (wild bergamot). Associated non-native species were chosen based on four criteria: 1) they were in the same family as the native species, 2) they were available from local horticulture suppliers, 3) they had similar physiology and cultivation requirements as their native counterparts, and finally, 4) they were not endemic to the Piedmont region of the United States.

Experimental design

During June – July in the summer of 2018, each combination of native/non-native was monitored during their peak bloom season, as described below. Each pair consisted of one native and one non-native plant of similar size and flower number. Native/non-native pairs were as follows: *Echinacea purpurea* and *Gaillardia aristata* 'Bijou' (Asteraceae), *Liatris spicata* and *Liatris ligulistylis* (Asteraceae), *Asclepias tuberosa* and *Asclepias curassavica* 'Red Butterfly' (Apocynaceae), and *Monarda fistulosa* and *Agastache rugosa* 'Golden Jubilee' (Lamiaceae). Non-natives were grown in sunken pots directly adjacent to the native plants to minimize site-specific abiotic differences. For monitoring, a total of six replicate pairs were studied overall on seven (*E. purpurea* and *G. aristata*), seven (*L. spicata* and *L. ligulistylis*), ten (*A. tuberosa* and *A. curassavica*), and eight (*M. fistulosa* and *A. rugosa*) different occasions, respectively.

Pollinator visitation frequency

Pollinator visitation measurements were based on previously established techniques (Frankie et al., 2002) with minor modifications. In short, inflorescences on each native/non-native replicate plant pair were monitored during each species' peak bloom season. During a 10-minute window, the total number of visiting insect pollinators was recorded for each native and non-native member of each replicate pair. We defined a pollinator "visit" as a period in which a pollinator landed on a flower long enough to engage in pollination activity. Pollinators moving from flower to flower on the same plant were not considered to have made additional "visits." However, pollinators leaving one plant and then returning within the 10-minute window were tallied for an additional "visit." The six replicates were measured in succession, with measurements taken in both the morning (08:00 – 10:00) and afternoon (14:00 – 16:00). We compared pollinator activity using a multi-factor ANOVA (Microsoft Excel v.16.16.5), assessing the effect of date, replicate (n = 6), time of day (morning or afternoon), and type of plant (native or non-native) on the number of pollinator visits.

The identification of insect pollinators in each plant pair was assessed by visual documentation (with reference to photographic and voucher specimens). All insects

visiting a replicate pair within each ten-minute observation period were identified to genus.

RESULTS

Insect pollinators

During the course of this study, we observed 25 different insect genera at the garden during monitoring periods (Table 1). In the genus, *Bombus,* three distinct species were observed. Overall insect genera fell into the following categories: bees (eight genera), flies (four genera), wasps (one genus), butterflies (ten genera), and beetles (two genera). Cumulatively, 11 genera (44%) were observed only on native floral species. There were no insect genera observed exclusively on non-native perennials.

Native/non-native pair visitation frequency

E. purpurea and *G. aristata*

The Piedmont native *E. purpurea* was compared to *G. aristata*, which is native to western and northern North America (USDA). Pollination measurements were conducted on these species between June 13 – July 19th, 2018, when the plants were in bloom locally.

Overall, *E. purpurea* experienced more pollinator visits than *G. aristata* (F_1 = 110.328, P < 0.001) (Figure 1A). Pollinator visitation also varied by collection date for all replicate pairs (F_6 = 4.701, P < 0.001), and more visitations were recorded during morning versus afternoon visits (F_1 = 103.754, P < 0.001).

More insect genera were observed on *E. purpurea* than on *G. aristata* during our monitoring period (Table 1). Insects seen interacting only with *E. purpurea* included seven bee taxa, four types of flies, and seven different butterflies or moths.

L. spicata and *L. ligulistylis*

The Piedmont native *L. spicata* was compared to *L. ligulistylis* (native to Central/Midwestern North America, USDA). *L. spicata* was found to attract a higher overall number of pollinator genera than *L. ligulistylis* (F_1 = 61.647, P < 0.001) (Figure 1B), although visitation frequency also varied by sample date (F_6 = 11.039, P < 0.001).

A wider variety of insect taxa was observed visiting *L. spicata* compared to *L. ligulistylis* (Table 1). In total, nine bee, two fly, eight different butterfly or moth, and one beetle taxa were observed visiting the native/non-native pair, and eleven of these seen were unique to *L. spicata*.

A. tuberosa and *A. curassavica*

The Piedmont native *A. tuberosa* was compared to *A. curassavica*, a Central/South American native (USDA). The native species, *A. tuberosa*, experienced a higher pollinator visitation frequency than *A. curassavica* (F_1 = 23.204, P < 0.001) (Figure 1C). In addition, visitation frequency was greater for both species during afternoon measurement periods (F_1 = 11.8, P < 0.001) and in some replicate pairs (F_5 = 3.413, P < 0.01).

More insect taxa were observed visiting *A. tuberosa* than *A. curassavica* (Table 1). The pollinators observed with this plant pairing were mostly bees – six taxa pollinated both native/non-native plant pairs, with only *Agopostemon virescens* and *Xylocopa virginica* unique to *A. tuberosa*. Only one butterfly species was observed during our monitoring periods; however, *D. plexippus* (Monarch butterfly) caterpillars were found on both plants later in the summer.

M. fistulosa and *A. rugosa*

The Piedmont native *M. fistulosa* was compared to *A. rugosa*, an East-Asian native. Insect pollinators visited *M. fistulosa* more frequently than *A. rugosa* (F_1 = 71.746, P < 0.001) Figure 1D), although both native and non-natives saw more frequent visitation during the afternoon (F_1 = 4.522, P < 0.05), and visits to both plant species decreased as the season progressed (F_7 = 6.043, P < 0.001).

M. fistulosa attracted more total insect groups than *A. rugosa* (Table 1). Between native/non-native pairs, we observed six bees, three flies, one wasp, and three butterfly or moth taxa. Two bee genera, *Halictus* and *Ceratina*, were unique visitors to the non-native *A. rugosa*.

DISCUSSION

Our goal in this investigation was to compare the visitation frequency as well as the overall variety of insect pollinators associated with native versus non-native perennial plants in an urban garden setting. As horticultural consumers are typically presented with a variety of touted "pollinator-friendly" perennials, the relative efficacy of native versus non-natives in this regard is an important factor for amateur gardeners to consider. Our findings revealed that, when comparing pairs of related, perennial native and non-native "pollinator-friendly" plant species, the natives were consistently visited by a higher total number of insects. Moreover, of the total variety of insect genera observed during our course of study, nearly half were associated only with native perennial species.

Our findings suggest that, when given a choice between two genetically and visually similar flowering perennials, more insects are likely to interact with a local native than with a non-native species. These results are consistent with studies performed under similar environs. For instance, Hanley et al. (2014) found that specialist bumblebees (*Bombus* spp.) in urban gardens tended to forage preferentially on plants native to their own biogeographical ranges. Likewise, a study by Fukase and Simons (2016) found that increased native plant species richness in urban Canadian gardens was correlated positively with pollinator foraging in those areas. These results, and those of our own study, argue for the preferential inclusion of locally native – rather than similar, non-native – plant species in urban landscape gardens.

Note must also be taken, however, of the difference between the need and niche requirements of different insect pollinators. Simply because a plant is native does not unilaterally make it more attractive to a visiting insect. Specialist pollinators, for instance, may require particular nutrients or habitats, while generalists are widely

adaptable. For instance, *Bombus impatiens* (Eastern bumble bee) is well-documented as a generalist pollinator and is widely managed for the pollination of agricultural crops (Kleijn and Raemakers, 2008). In our study, *B. impatiens* was the only insect observed interacting with all eight plant species. Several studies have noted the likelihood of non-native plant species to appeal more strongly to generalist pollinators (Albrecht et al., 2014) and question the need to prioritize native plantings in urban gardens (Hanley et al., 2014; Goddard et al., 2010). However, the mechanisms for this preference remain unclear and are likely species-specific, based on particular floral characteristics (Corbet et al., 2001; Poythress and Affolter, 2018). Until the mechanisms responsible for these observations are clarified, it is unwise to generalize the value of native versus non-native plants to plant-pollinator interactions.

During the course of our study, we also observed several insect taxa that visited only native plants. In a few cases, an insect pollinator was seen on one native plant species and no others. *Vanessa virginiensis* (American painted lady), for instance, visited only the native *E. purpurea*. *V. virginiensis* is a specialist butterfly whose larvae preferentially feed on plants in the family Asteraceae (such as *E. purpurea*) (Holm, 2014). Specialist insects, whether pollinators or otherwise, are closely dependent on their coevolutionary floral counterparts. The inclusion of beneficial host plants in urban gardens has been suggested to increase the abundance of specialist pollinations in those areas (Harrison and Winfree, 2015), and have the potential to provide resources in fragmented urban habitats.

Interestingly, all of the 10 butterfly genera observed in our study visited one or more native plant species. Of these, 7 visited natives exclusively. We observed a unanimous preference for *E. purpurea* over *G. aristata*, and *L. ligulistylis* was the only non-native visited by more than one type of butterfly. One reason for such a distinct disparity in visitation frequency may stem from our use of horticultural cultivars as non-native counterparts in this study. Horticultural cultivars are wild-type plants that have been bred specifically to present certain qualities. In the case of urban landscape gardens, such qualities might include differences in flower color or morphology. These changes, while desirable to the urban gardener, may be unappealing to pollinators or other insects (Comba et al., 1999). Emergent studies have suggested that horticultural cultivars may provide less benefit in terms of nutrient quality and floral reward (Comba et al., 1999; Corbet et al., 2001; Pothyress and Affolter, 2018). Although the study of horticultural cultivars versus non-cultivars was not a part of our study, it is worth note that, *L. ligulistylis*, the non-native most frequented by butterflies, was also the only non-native non-cultivar.

Prolificacy of urban green space is a good option for many reasons. In our study, the demonstrated pollinator preference for native plant species supports the prioritization of native plant species in urban landscapes. As has been shown in previous studies, increasing the proportion of native plants can also increase the proportion of rare or specialized pollinators (Fukase and Simon 2016). In our study, pollinator preference for the native was maintained despite the choice for a nearby non-native, although several scaled factors may have influenced this preference (Mitchell et al., 2009; Kantsa et al.,

2018), from providing an idealized reward to fine-tuning its accessibility. While such was not our goal, the identification and assessment of these factors are also likely to play a role in increasing and preserving pollinator activity in urban landscape gardens.

To conclude, our study provides a baseline for understanding pollinator presence in our local area and supports the argument for including native flowering perennials in the garden. With worldwide insect populations in likely decline (Hallmann et al., 2017; Lister and Garcia, 2018), urban green spaces are proving to be even more essential. Future studies on plant-pollinator relationships and the role of native species in the urban landscapes will lend a more ecological understanding to our horticultural choices and help us to harmonize the aesthetics with the efficacy of our own local gardens in the larger, urban ecosystem.

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NR participated in study design, data collection and analysis, and manuscript preparation. BS participated in study design, data analysis, and manuscript preparation. SR and EM participated in data collection and analysis.

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TABLE 1. Insects observed interacting with study plants during monitoring periods.

Pollinators		Native	Non-native	Native	Non-native	Native	Non-native	Native	Non-native
Latin	**Common**	***E. purpurea***	***G. aristata***	***L. spicata***	***L. ligulistylis***	***A. tuberosa***	***A. curassavica***	***M. fistulosa***	***A. rugosa***
Bombus pensylvanicus	American bumble bee	x						x	
Bombus impatiens	Eastern bumble bee	x	x	x	x	x	x	x	x
Bombus griseocollis	Brown-belted bumble bee			x					
Xylocopa virginica	Eastern carpenter bee	x		x		x		x	
Ceratina spp.	Small carpenter bee					x	x		x
Halictus spp.	Sweat bee	x		x		x	x		x
Agapostemon virescens	Green sweat bee	x	x	x	x	x			
Lasioglossum spp.	Sweat bee	x	x	x		x	x	x	x
Augochlora pura	Sweat bee			x	x	x	x		
Apis mellifera	Honey bee	x		x	x	x	x	x	x

Syritta pipiens	Thick-legged hoverfly	x		x		x			
Toxomerus geminatus	Syrphid fly	x	x	x	x	x		x	
Eristalis tenax	Drone fly	x	x					x	
Lucilia sericata	Green bottle fly	x	x			x	x	x	
Vespula spp.	Yellow jacket wasps							x	x
Speyeria cybele	Great spangled fritillary	x							
Vanessa virginiensis	American painted lady	x							
Pieris rapae	Cabbage white	x		x	x				
Alypia octomaculata	Eight-spotted forester	x		x					
Danaus plexippus	Monarch	x		x	x				
Polites themistocles	Tawny-edged skipper	x		x			x		
Epargyreus clarus	Silver-spotted skipper	x		x	x			x	x

Erynnis spp.	Dusky wing skipper			x					
Phycoides spp.	Crescent butterfly					x			
Hemaris diffinis	Snowberry clearwing			x				x	
Diabrotica undecimpunctata howardii	Spotted cucumber beetle			x					
Labidomera clivicollis	Milkweed leaf beetle					x	x		

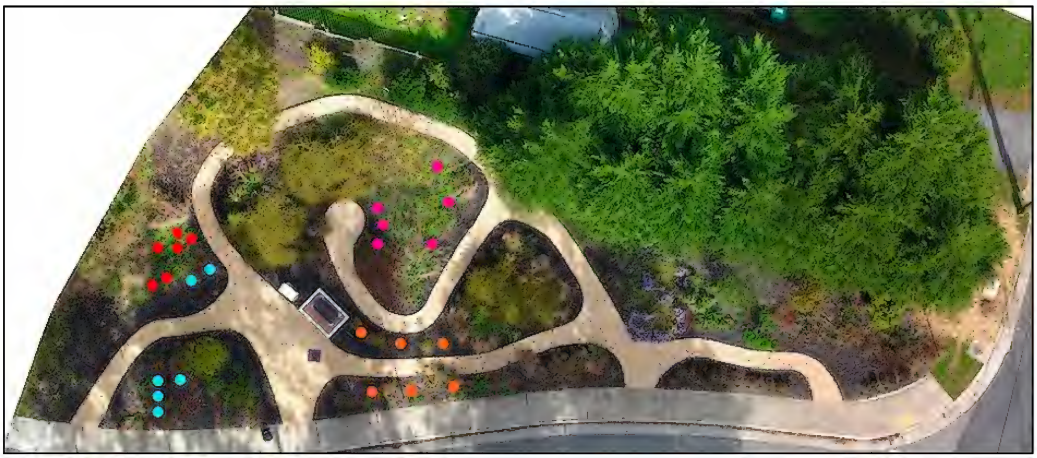

FIGURE 1. Aerial view of the Randolph-Macon College Brian Wesley Moores native plant garden. Plant pair locations are indicated with circles (Red = *E. purpurea*, Blue = *L. spicata*, Orange = *A. tuberosa*, Magenta = *M. fistulosa*). For scale, the square drone landing pad along the walking path is 3' x 3'. Photo credit to John McManus (Randolph-Macon College), taken on Oct. 28th, 2018.

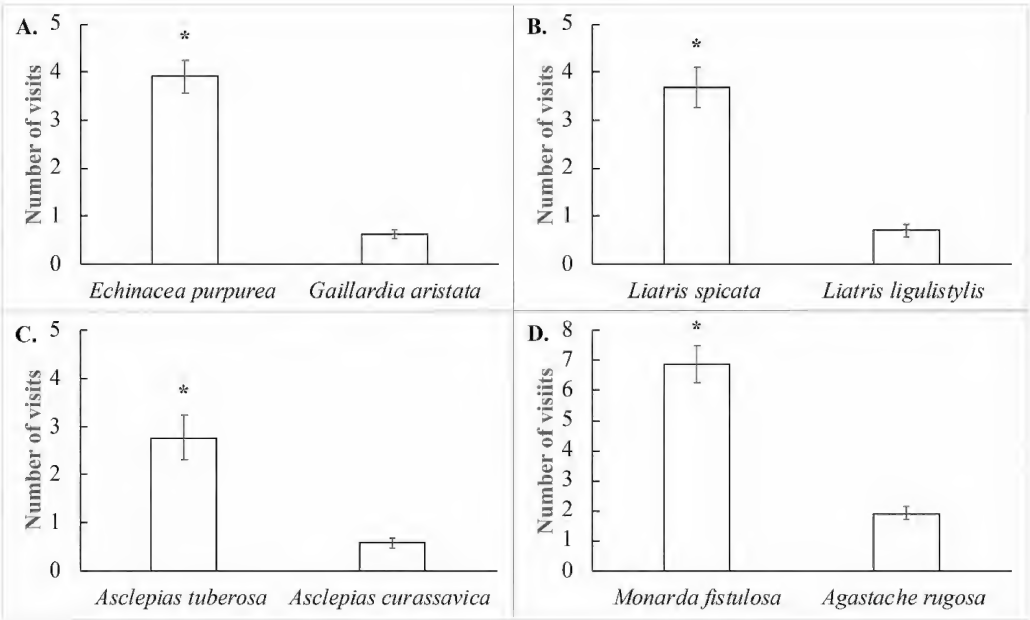

Figure 2. Comparison of mean pollinator visitation frequency to native/non-native paired plant sets showed a significantly higher number of visits made to native plants. Asterisks (*) represent significant differences ($p<0.001$) in visitation frequency. Error bars represent ±SE.

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Predicting Dissertation Methodology Choice Among Doctoral Candidates at a Faith-Based University

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ABSTRACT

Limited research has investigated dissertation methodology choice and the factors that contribute to this choice. Quantitative research is based in mathematics and scientific positivism, and qualitative research is based in constructivism. These underlying philosophical differences posit the question if certain factors predict dissertation methodology choice. Using the theoretical framework of intersectionality, this predictive, correlational study used archival data to determine if biological sex, ethnicity, age, or religious affiliation predicts dissertation methodology choice. A logistics regression analysis was used to review 398 doctoral dissertations and determine if any of the criterion variables predicted dissertation methodology choice. After analysis, it was determined that none of the criterion variables of biological sex, ethnicity, age, and religious affiliation were statistically significant in predicting dissertation methodology choice.

Keywords: doctoral dissertation, research methodology, quantitative research, qualitative research

INTRODUCTION

The doctoral dissertation is a capstone product among doctoral programs in many disciplines (Boote & Beile, 2005), with two main methodological choices: quantitative and qualitative. These two methodologies are fundamentally different, and there is little research that discusses how doctoral candidates choose one of these methodologies over the other. The fundamental differences between these two methodologies originate from the core of their philosophical assumptions (Guba, 1990). Quantitative research is based in positivism and focuses on empirical observation and scientific study (Sale, Lohfeld, & Brazil, 2002), whereas qualitative research is based in constructivism (Creswell, 2013).

Quantitative research, founded in the positivist paradigm, is based on empirical studies and is common in hard science fields (Sale et al., 2002). In quantitative research, the researchers study a phenomenon objectively, sample sizes are larger than in qualitative studies, and structured protocols and randomization are emphasized. Quantitative research embodies more mathematical and traditional, scientific experimental research (Sale et al., 2002). Furthermore, the philosophical assumptions of positivism drive this methodology. Positivism is, according to Creswell (2013), reductionistic, logical, and case-and-effect oriented. Individuals with a positivist belief system are deterministic, or they believe that every action is the effect of a specific antecedent that caused that consequence (Creswell, 2013).

In contrast, qualitative research is based in constructivism. Qualitative researchers have a goal of relying on participants' views, meanings, and experiences (Creswell, 2013). This methodology relies on in-depth interviews, focus groups, observations, and document reviews with a much smaller sample size than that of quantitative research. Its philosophical underpinning is constructivism. Constructivism is a paradigm in which individuals seek to understand the world. They rely on experiences of people around them, and that reality is created through individual experiences and interactions with others (Creswell, 2013). In a constructivist paradigm, it is believed that "multiple realities are constructed through our lived experiences and interactions with others" (Creswell, 2013, p. 36).

Though quantitative research has been a more traditionally used methodology among dissertation candidates, qualitative research has risen dramatically in the past 30 years (Rone, 1998) and at the same time, more women are graduating with doctoral degrees (Nelson & Coorough, 1994; U.S. Department of Education, National Center for Education Statistics, 2015). Because qualitative research may include more traditionally feminine characteristics in its research and analysis methods, such as interpersonal relationships (Creswell, 2013; Lincoln & Guba, 1985), one could surmise that qualitative research has increased in part because of the higher percentages of women completing doctoral degrees.

There is very little research regarding the choice between a quantitative or qualitative research methodology among doctoral candidates. In each methodology, which involves very different data collection methods and analysis procedures, it is unknown through current research if there are predictors for those who choose to pursue each methodology (Creswell, 2013; Sale et al., 2002). Feminist research has indicated that the positivist assumptions in quantitative research do not align with the female identity (Stanley & Wise, 1983), and other research has suggested that women have higher levels of mathematics anxiety, which could indicate that women are more likely to choose qualitative research (Cheryan, 2012; Nelson & Brammer, 2008). Individuals of African American or Hispanic ethnicities may also be more likely to choose qualitative research because various studies have shown a higher level of mathematics anxiety and poorer levels of mathematics performance among these subgroups (Bell, 2003; Bui & Alfaro, 2011; Lockhead, Thorpe, Brooks-Gunn, Casserly, & McAloon, 1985;

Onwuegbuzie & Wilson, 2003; Upadyaya & Eccles, 2014; Wilson & Milson, 1993). Non-traditional students, or students older than the average graduate student, may also chose the qualitative methodology more often based on their statistics anxiety and attitudes towards mathematics and science (Bean & Metzner, 1985; Bell, 2003; Bui & Alfaro, 2011; Jones & Watson, 1990; Lockhead et al., 1985; Onwuegbuzie & Wilson, 2003; Upadyaya & Eccles, 2014; Wilson & Milson, 1993). Finally, a candidate's religious world view may affect their choice of methodology as there appears to be an underlining conflict between scientific research that is based in positivism and a religious affiliation (Astley & Francis, 2010; Greer, 1990; Sale et al., 2002).

According to Plowman and Smith (2011), there is not enough research regarding dissertation methodology choice among men, women, and various other demographic groups and why individuals pursue one type of research methodology over the other. This study seeks to add to the existing body of research and to determine if there are differences between the choice of dissertation methodology among men and women as well as the role that ethnicity, age, and religious affiliation play on a doctoral candidate's methodology choice (Borders, Wester, Fickling, & Adamson, 2015; Goodrich, Shin, & Smith, 2011; Plowman & Smith, 2011). This study hopes to provide insight into dissertation methodology choice for both men and women, and deepen the understanding of ethnicity, age, and religious affiliation in the math and science fields.

OVERVIEW OF RELATED LITERATURE

Theoretical framework.

The concept of intersectionality, which is drawn from critical theory, specifically considers the interactions of categories of differences in individual lives. This can include gender, race, and other categories of difference, which, for the purpose of this study, includes religion (Davis, 2008). Shields (2008) defined intersectionality as "social identities which serve as organizing features of social relations, mutually constitute, reinforce, and naturalize one another" (p. 302). Similarly, Collins (1998) defined intersectionality as "rather than examining gender, race, class, and nation as distinctive social hierarchies, intersectionality examines how they mutually construct one another" (p. 62). Dimensions of identity, such as gender, religion, and race are not independent additions that add up to an identity, but they are interdependent on each other (Bowleg, 2008; Warner, 2008). Crenshaw (1989) was one of the first to define intersectionality and apply it to dimensions of identity that are more than the sum of each part. Crenshaw (1989) specifically studied African American women and stated, "because the intersectional experience is greater than the sum of racism and sexism, any analysis that does not take intersectionality into account cannot sufficiently address the particular manner in which Black women are subordinated" (p. 140). Identities are formed in relation to one another, and the process of merging various identities is transformative. This merge produces an entirely new sense of self; it is not just an intersection of identities.

The focus of these aspects of identity is how they interconnect rather than just their similarities and differences (McCann & Kim, 2002). The framework of

intersectionality is based in social constructivism, which maintains that aspects of identity are constructed from aspects of social, historical, political, and cultural factors (Omi & Winant, 1994). Intersectionality supports a social identity, or an identity that is formed through social interactions and cultural factors (Shields, 2008). Multiple dimensions of identity, such as gender, race, religion, socioeconomic status, and nationality are complex social processes that intersect with each other rather than exist independently (Bowleg, 2008). Because this study involves the examining of ethnicity and gender, along with age and religion, intersectionality is an appropriate framework (Cole, 2009, Else-Quest, Mineo, & Higgins, 2013).

Quantitative and qualitative research.

There are two main methodological choices in research: quantitative or qualitative. These two methodologies are fundamentally different in their philosophical paradigms, language, and data collection methods. Quantitative research is based on positivism (Sale et al., 2002) and maintains objective reality. In contrast, qualitative researchers believe that reality subjective and is constantly changing and is created through individuals' experiences (Sale et al., 2002). The choice between each of these methodologies is a complex one with little research examining how doctoral candidates select one methodology over the other. Buchanan and Bryman (2007) discussed how the choice between research methods is "shaped by aims, epistemological concerns, norms of practice…as well as historical, political, ethical, evidential, and personal factors" (p. 483). In their discussion, they pointed out that the combination of personal characteristics in the context of choosing a research methodology are "naturally occurring and unavoidable influences" (p. 483).

Biological sex and methodology choice.

Quantitative research is based in mathematics, which is evidenced in the statistical analysis that is used to analyze data in this methodology (Sale et al., 2002). There is an abundance of research that has indicated that women have higher mathematics anxiety, lower mathematics attitudes, and are less confident than men in their mathematics abilities (Bell, 2003; Bui & Alfaro, 2011; Eccles & Wigfield, 2002; Lockhead et al., 1985; Nelson & Brammer, 2008; Onwuegbuzie & Wilson, 2003). Studies have also indicated that women have higher statistics anxiety than men (Onwuegbuzie, 1995; Zeidner, 1991), which is directly related to quantitative methodologies, because it usually requires statistical analysis. Royce and Rompf (1992) also found that women have more difficulties in statistics and in quantitative methodologies in general. Zeidner (1991) postulated that the reason that women have more statistics anxiety and difficulties is because of their prior experiences in math, including low mathematics self-efficacy, which has been theorized to be a product of gender stereotyping and low mathematics performance. These difficulties with statistics may provide insight into why Plowman and Smith (2011) found that in four different scholarly journals, women publish more qualitative studies than men and men publish more quantitative studies than women. While older research and meta-analyses is clear of the mathematics performance gap between men and women, recent research has also indicated that due to a growing gender equality across modern cultures, females have reached parity with males in mathematics performance, at least in the school-aged students studied (Hyde & Mertz, 2009).

However, since doctoral students have not yet been studied and generally have an older average age of 42 than most educational programs, it is unknown if this sociocultural change has reached women in the older generation.

Ethnicity and methodology choice.

Research has indicated that individuals of several ethnic minorities experience stereotype threat in mathematics (Hughes, Gleason, & Zhang, 2005). In addition, African American and Hispanic individuals have higher mathematics anxiety, poorer mathematics performance, and lower science and mathematics attitudes than Caucasians or Asians (Bell, 2003; Bui & Alfaro, 2011; Lockhead et al., 1985; Onwuegbuzie & Wilson, 2003; Wilson & Milson, 1993). Lockhead et al. (1985) conducted a meta-analysis of multiple studies and found that Asian American students had higher mathematics performance than Caucasian students, both Asian American and Caucasian students had higher mathematics performance than Hispanic students, and all three of the groups had higher mathematics performances than African American students. Grigg, Donahue, and Dion (2007) examined mathematics assessments and found that Asian Americans scored highest, followed by Caucasian students. African American students and Latino students scored the lowest on these mathematics exams. Gross (1988) found that as students got older, African American and Hispanic students found science and mathematics less enjoyable than their Caucasian and Asian American counterparts. Because quantitative research is based in mathematics and positivism (Sale et al., 2002), this may indicate that those in ethnic minorities may be more likely to choose qualitative methodologies rather than quantitative.

Age and methodology choice.

Older students tend to have higher mathematics anxiety and lower attitudes towards mathematics and science compared to their younger, traditional-student counterparts (Bean & Metzner, 1985; Jones & Watson, 1990; Lockhead et al., 1985). Bui and Alfaro (2011) discovered that both statistics anxiety and attitudes toward science differed by age. Research has indicated that mathematics anxiety increases with age, attitudes toward mathematics and science decrease with age, and age is the most significant predictor of attrition in undergraduate and graduate programs (Bean & Metzner, 1985; Bell, 2003; Bui & Alfaro, 2011; Jones & Watson, 1990; Lockhead et al., 1985; Onwuegbuzie & Wilson, 2003; Upadyaya & Eccles, 2014; Wilson & Milson, 1993). Age is also a defining factor in the determination of a student as traditional or non-traditional (U.S. Department of Education, National Center for Education Statistics, 2016a). Because research indicates that older, non-traditional students may face higher mathematics anxiety and lower performance in mathematics and science, it is important to examine if these factors may affect their dissertation methodology choice.

Religion and methodology choice.

To complicate the issue of methodology choice, the salience of religious affiliation may also influence the choice of dissertation methodology. For people of religious faith, embracing modern science in its entirety can be difficult. Cho (2012) described the difficulties of clashing worldviews. Scientific inquiry is based in positivism--the claim that empirical observations are considered true--which contrasts

with the theistic metaphysical beliefs of those of religious faith. Science, and more specifically, positivism, rejects any metaphysical conclusions that anything other than what can be seen exists. This rejects the existence of a superior being and directly contradicts the worldview of those with religious faith. Researchers have found that there is a negative correlation between attitudes toward science and attitudes toward religion (Astley & Francis, 2010), and in a study conducted by Francis and Greer (1999), it was found that 62% of students agreed that there is a fundamental conflict between scientific and religious claims. Keele (2012) described quantitative research as based in "hard science." These philosophical differences between science, and thus, quantitative research methods and religious faith, could cause people of religious affiliation to reject quantitative research methods in favor of qualitative methods that encompass a more subjective analysis to embrace their differences in perspective and philosophy.

METHODS

Research design.

This study utilized a predictive correlational design to examine if the variables of biological sex, ethnicity, age, and religious affiliation help predict the choice of a quantitative or qualitative dissertation methodology among doctoral candidates. A logistic regression was used to examine the relationship between the predictor variables (biological sex, ethnicity, age, and religious affiliation) and the criterion variable, dissertation methodology choice (quantitative or qualitative). *Biological sex* was defined as male or female (American Psychological Association, 2011). *Ethnicity* was defined as the "social group a person belongs to, and either identifies with or is identified with by others, as a result of a mix of cultural and other factors including language, diet, religion, ancestry, and physical features traditionally associated with race" (Bhopal, 2004, p. 443). *Age* was defined as how old in years the candidate was at the time of the dissertation defense. *Religious affiliation* was defined as "an organized system of practices and beliefs in which people engage" (Mohr, 2006, p. 174). A quantitative method is defined as a systematic and objective method of research that utilizes numerical data to describe variables, observe relationships among variables, or determine cause and effect relationships between variables (Burns & Grove, 2005). A qualitative method is defined as a method that is "multimethod in its focus, involving an interpretive, naturalistic approach to its subject matter…qualitative researchers study things in their natural settings, attempting to make sense of, or interpret phenomena in terms of the meanings people bring to them" (Denzin & Lincoln, 1994, p. 2). No candidates in the sample completed a mixed-methods dissertation.

Participants and setting.

The participants in this archival study were education doctoral candidates from a large, private, faith-based university in the southeast with an Ed.D. (Doctor of Education) degree. To determine the effect of biological sex, ethnicity, age, and religious affiliation on dissertation methodology choice among doctoral candidates, data were analyzed for the criterion variable, dissertation methodology choice (quantitative or qualitative). After two cases were removed due to incomplete data, the sample included 388 dissertations. There were 199 quantitative dissertations and 189 qualitative dissertations included in the study. There were 257 female students in the sample and 131 male students. Ethnic

breakdown included 286 Caucasian students, 38 African American students, eight Hispanic students, four Asian students, six American Indian students, and 46 students with no ethnicity specified. There were 198 non-traditional aged dissertation authors and 190 traditional-aged dissertation authors. There were 187 students who identified with a religion and 201 who did not identify with a faith. The demographics of the sample in each group can be seen in Table 1.

Table 1

Frequencies for Predictor Variables for Dissertation Methodology

Predictor Variable	Quant. Diss. (n = 199)	Qual. Diss. (n = 189)
Biological sex		
Female	132	125
Male	67	64
Ethnicity		
Caucasian	143	143
Af. American	23	15
Hispanic	2	6
Asian	3	1
Am. Indian	3	3
Not specified	25	21
Age		
Non-traditional	95	103
Traditional	104	86
Religious affiliation		
No rel. aff.	101	100
Rel. aff.	98	89

Notes. Af. American = African American, Quant. Diss. = Quantitative Dissertation, Qual. Diss. = Qualitative Dissertation, Rel. aff. = Religious affiliation.

The Ed.D. degree at this university is a blended or hybrid program, requiring both online and residential doctoral courses. Considering the university setting is a faith-based institution, it could be expected that students at this university were affiliated with a religion. However, this cannot be assumed. In Uecker's (2008) study, it was found that students at faith-based schools are more likely than students at secular schools to believe that religious faith is important in daily life, but not all students at faith-based schools identify as affiliated with a religion. Although religious schools do reinforce religious faith, religious schooling is not a definitive predictor of religious faith or affiliation (Uecker, 2008). In this study, if the dissertation candidate indicated his or her religious affiliation on the application to the university, it was an assumption that religious faith is

a salient identity role, which is supported by Jones and McEwen's (2000) multi-dimensional identity theory. Although doctoral candidates who did not indicate their religion on their university application still may have a religious affiliation, it was not considered a salient identity trait for the purposes of this study (Jones & McEwen, 2000).

There were 590 dissertations that were written by Ed.D. candidates at this university between the years of 2012-2016 as determined by the records of the School of Education. In 2011, a new system was implemented for dissertation candidates in which a research consultant was assigned to each candidate to review his or her methodology and analysis to ensure he or she met the university requirements. The dissertations accepted by the university's School of Education are traditional in nature and consist of five chapters: Introduction, Literature Review, Methods, Results, and Conclusions. Both qualitative and quantitative methods are accepted for the dissertation requirement, and the School of Education's Dissertation Handbook states that for quantitative studies, a candidate can choose experimental, quasi-experimental, causal-comparative, and correlational designs. For qualitative studies, a candidate can choose phenomenological, grounded theory, case study, historical, and ethnographic designs. Any other research designs require special permission from the administration of the program.

Data collection.

Archival, descriptive data were used for this study. Data were gathered using Banner INB and the Digital Commons database. Banner INB was hosted on the university's network and uses online forms to both enter and search information in the database. First, admissions counselors enter demographic information about students as they apply for the university. Throughout a student's program, academic advisors, financial aid employees, and employees of the registrar's office enter information in a student's profile. The student's profile includes his or her birthdate, ethnicity, religious affiliation, contact information, and grades from courses taken. Digital Commons, a publication database, houses faculty- and student-edited scholarly journals, works from university faculty, and student theses and dissertations. Digital Commons is hosted on the university library's website, and it is maintained by the library's staff. Once a candidate successfully defends his or her dissertation and the committee has approved the final manuscript, the candidate is required to send the final dissertation to the library staff for publication in Digital Commons. The library staff reviews dissertations for copyright purposes and uploads the dissertation as a PDF file into the Digital Commons database.

Procedures.

Appropriate approvals were also granted by the university Institutional Review Board (IRB) before data analysis began. A sample of 388 completed dissertations were used in this study from the years 2012-2016 after two cases were removed due to incomplete data. Upon examining each dissertation, the researchers first looked to see if the words "quantitative" or "qualitative" appeared in the abstract. If so, the researchers categorized the dissertation in a column on an Excel sheet with dummy coding. If neither of the words "quantitative" or "qualitative" appeared in the abstract of the dissertation, the researchers looked for the terms "statistical method" or "non-statistical method." If "statistical method" was used, the researchers categorized the dissertation as quantitative.

If "non-statistical method" was used, the researchers categorized the dissertation as qualitative. Next, the researchers looked for the words "experimental," "quasi-experimental," "causal-comparative," or "correlational." If any of these words were used in the abstract, the researchers categorized the dissertation as quantitative. If these words were not mentioned in the abstract, the researchers looked for the words "phenomenology," "grounded theory," "case study," "historical," or "ethnographic." If any of these words were used in the abstract, the researchers categorized the dissertation as qualitative. If none of these key words were found in the abstract of the dissertation, the researchers examined the methodology chapter of the dissertation to determine if statistical analysis was used as the main form of data analysis. If statistical analysis was used as the main form of data analysis, the dissertation was categorized as quantitative. If the main form of data collection and analysis was interviews, observations, or focus groups, the dissertation was categorized as qualitative. While viewing each dissertation, the researchers also noted the page length of the dissertation as well as the specific methodology (experimental, quasi-experimental, causal-comparative, correlational, phenomenology, grounded theory, case study, historical, or ethnographic).

Biological sex was determined based on the candidate's self-reported sex, male or female, listed on the candidate's profile in the university's administrative database. Ethnicity was also determined based on the candidate's self-reported profile in the university's administrative database. The candidate's age was determined by subtracting the birthdate listed on the university's administrative database from the year the candidate's dissertation was defended. According to the U.S. Department of Education (2010), the average age of a student in an Ed.D. program is 42.3 years old. The National Center for Education Statistics (2015) defined a non-traditional student as a student above the average age of the program. Thus, any student aged 43 years and older and above was categorized as a non-traditional student, and any student with an age under 42 years and younger was categorized as a traditional student.

Data analysis.

Descriptive statistics were calculated for each of the predictor variables (biological sex, ethnicity, age, and religious affiliation) and criterion variable (quantitative or qualitative). Table 1 includes a complete listing of the descriptive statistics and demographic characteristics of the students who chose quantitative and qualitative dissertations.

A logistic regression analysis was used to test the effect of biological sex, ethnicity, age, and religious affiliation on dissertation methodology choice among doctoral candidates in the School of Education at a faith-based university. A Wald ratio was reported for the logistic regression model. Cox and Snell's and Nagelkerke's statistics were used to measure the strength of the model. Logistic regression was used because the criterion variable was categorical and dichotomous (Gall, Gall, & Borg, 2007).

In addition to the logistic regression analysis, which determined the correlation between the criterion variable (dissertation methodology choice) and the predictor

variables (biological sex, ethnicity, age, and religious affiliation), odd ratios were also calculated to determine the chance that each of the predictor variables had on predicting the methodology chosen.

RESULTS

Results for null hypothesis.

A binary logistic regression analysis was used to test the relationship between the predictor variables (biological sex, ethnicity, age, and religious affiliation) and the criterion variable (dissertation methodology) at a 95% confidence level. Because each of the variables were categorical, they were each dummy-coded. Data screening was conducted and the appropriate assumptions tests were conducted before running the logistic regression (see Warner, 2008). All assumptions were met. The results of the binary logistic regression were not statistically significant, $\chi^2(8) = 6.34$, $p = .61$. The model was extremely weak according to Cox and Snell's ($R^2 = .016$) and Nagelkerke's ($R^2 = .022$) parameters. There was no statistically significant, predictive relationship between dissertation methodology choice (quantitative or qualitative) and the predictor variables (biological sex, ethnicity, age, religious affiliation). Thus, the researchers failed to reject the null hypothesis.

The researchers further investigated the variable coefficients. For the variable of biological sex, the Wald ratio was not statistically significant, $\chi^2(1) = .01$, $p = .91$. This result indicated that dissertation methodology choice between male and female candidates was not statistically significant. The odds ratio for biological sex was 1.03 indicating that women were 1.03 times more likely to choose a quantitative methodology than men. However, this relationship was too small to be considered statistically significant, as indicated by the Wald statistic.

The researchers also investigated the predictor variable of ethnicity. Overall, the predictor variable of ethnicity was not statistically significant, $\chi^2(5) = 3.97$, $p = .55$. In addition, none of the Wald ratios for any ethnic groups were statistically significant. For students with a Caucasian ethnicity, the Wald ratio was not statistically significant, $\chi^2(1) = .96$, $p = .33$. The odds ratio for Caucasian students was .69, indicating that Caucasian students were .69 times more likely to choose a quantitative methodology. For students with an African American ethnicity, the Wald ratio was not statistically significant, $\chi^2(1) =.35$, $p = .56$. The odds ratio for African American students was 1.21, indicating that African American students were 1.21 times more likely to choose a quantitative methodology. For students with a Hispanic ethnicity, the Wald ratio was not significant, $\chi^2(1) = .188$, $p = .67$. The odds ratio for Hispanic students was .821, indicating that Hispanic students were .821 times more likely to choose a quantitative methodology. For students with an Asian ethnicity, the Wald ratio was not significant, $\chi^2(1) = 2.16$, $p = .14$. The odds ratio for Asian students was 3.59, indicating that Asian students were 3.59 times more likely to choose a quantitative methodology. For students with an American Indian ethnicity, the Wald ratio was also not significant, $\chi^2(1) = .43$, $p = .51$. The odds ratio for American Indian students was .46, indicating that American Indian students were .46 times more likely to choose a quantitative methodology. Finally, for students who did not specify their ethnicity, the Wald ratio was also not significant, $\chi^2(1) = .03$, p

= .855. The odds ratio for students who did not specify their ethnicity was 1.17, indicating that not specify students were 1.17 times more likely to choose a quantitative methodology.

The researchers also examined age, and for this variable, the Wald ratio was also not statistically significant for this variable, $\chi^2(1) = 1.24$, $p = .27$. This result indicated that there was no significant relationship in dissertation methodology choice between traditional students (42 and younger) and non-traditional students (age 43 and older). The odds ratio for age was 1.26, indicating that traditional students were 1.26 times more likely to choose a quantitative methodology than non-traditional students. However, this relationship was too small to be considered statistically significant, as indicated by the Wald statistic.

Finally, the researchers investigated religious affiliation. For the variable of religious affiliation, the Wald ratio was not statistically significant, $\chi^2(1) = .17$, $p = .68$. This result indicated that there was no significant difference in dissertation methodology choice between students who are affiliated with a religion and those who are not affiliated with a religion. The odds ratio for religious affiliation was 1.09, indicating that students with no religious affiliation were 1.09 times more likely to choose a quantitative methodology than students with a religious affiliation. However, this difference was too small to be considered statistically significant, as indicated by the Wald statistic.

DISCUSSION

The purpose of this archival, predictive correlational study was to examine the effect of biological sex, ethnicity, age, and religious affiliation on dissertation methodology choice among doctoral candidates in the School of Education at a faith-based university. Research suggests that qualitative research embodies more feminine characteristics such as a focus on interpersonal relationships and an underlying constructivist approach (Creswell, 2013; Lincoln & Guba, 1985), but research has also indicated that women are over-represented as authors of qualitative studies (Plowman & Smith, 2011). Plowman and Smith (2011) studied published research journal studies, not dissertations, and although their study was published in 2011, the data they collected was from a 22-year period from 1986-2008. In the present study, when looking at candidates' dissertations, men and women were equally as likely to conduct a quantitative or qualitative study. This was in contradiction to Plowman and Smith's (2011) findings. This may be explained due to an overall increase in qualitative research within recent years and because women may now be more willing to overcome any math anxiety.

As Rone (1998) indicated, qualitative research has been steadily increasing since 1980, quickly becoming a research method used as often as the more traditional quantitative method, especially in the social science and education fields. Because this study collected data from 2012-2016, it includes much more recent data. This study's data was also collected from only Ed.D. doctoral candidates, which is one of the fields where qualitative research is most popular (Rone, 1998). It is possible that qualitative research is continuing to rise in popularity and is becoming a more often used methodology for both genders.

Regarding math anxiety and women, a dissertation is usually divided into five chapters: introduction, literature review, methods, analysis, and discussion. Even though a quantitative methodology is based in a positivist philosophical approach (Sale et al., 2002) which differs from the qualitative constructivist approach (Creswell, 2013), three of the five chapters of the dissertation are structured and written the same in both qualitative and qualitative studies (Bloomberg & Volpe, 2015). Although research has shown that women have higher levels of math anxiety than men and pursue degrees in mathematical fields at a much lower percentage than men (Cheryan, 2012; Nelson & Brammer, 2008), because the quantitative dissertation only includes math-related concepts in two of the five chapters, women may be more willing to overcome any math anxiety for just two chapters of a dissertation than they would be for a career or advanced degree in a math-related field. Recent research has also indicated that due to a growing gender equality across modern cultures, females have reached parity with males in mathematics performance, at least in the school-aged students studied (Hyde & Mertz, 2009). Even though this has not been examined in doctoral programs, it is possible that the sociocultural factors in the United States have contributed to equality among both genders of all ages in mathematics performance.

Ethnicity and methodology choice.

In this study, ethnicity was not found to be a statistically significant predictor of dissertation methodology choice. Although previous research has found that several ethnic minorities experience more stereotype threat, higher mathematics anxiety, and lower mathematics attitudes than Caucasians or those of Asian descent (Bell, 2003; Bui & Alfaro, 2011; Lockhead et al., 1985; Onwuegbuzie & Wilson, 2003; Upadyaya & Eccles, 2014; Wilson & Milson, 1993), this study did not find that this translated into more qualitative dissertation methodologies for candidates of any specific ethnic minority. Previous research has also indicated that individuals of an ethnic minority tend to avoid math and science majors (Tobias, 1976). However, much of the research in this area is outdated, and although avoidance of careers and major areas of study in the mathematics field is documented in prior research, in this study, individuals of some ethnic minorities were just as likely to complete quantitative dissertations as individuals of Caucasian descent. This could be an indication of the mathematics anxiety, achievement, and attitudes gaps closing, or it could be indicative that these candidates were able to overcome their anxiety regarding the two chapters of the dissertation related to mathematics.

Age and methodology choice.

Although statistics anxiety is higher in older, non-traditional students compared to traditional students (Baloglu, 2003), in this study non-traditional students were just as likely to choose a quantitative dissertation methodology as traditional students. In Baloglu's study, it was found that older students had higher statistics anxiety than younger students, but older students had more positive attitudes towards statistics than younger students. Baloglu noted that older students recognized the value and usefulness of statistics. Even though the non-traditional candidates' statistics anxiety may have been higher based on previous research, there was not a statistically significant relationship

between their methodology choice and age. As previously mentioned, two of the five dissertation chapters include statistical analyses in a quantitative dissertation. It could be that non-traditional students understand the value of statistics and the quantitative methodology and persist through any statistics anxiety in the chapters in the dissertation that require statistics.

Religion and methodology choice.

In this study, religious affiliation was not found to be a statistically significant predictor of dissertation methodology choice. Even though quantitative methodologies are based in positivism, which conflicts with the worldview of most religions, candidates at this university with a religious affiliation were not less likely to choose a quantitative dissertation methodology. It could be that using a positivist approach in a dissertation is separate from an individual's personal, religious worldview. As Taber, Billingsley, Riga, and Newdick (2011) found, some students believe that science, which is both positivist and focused on empirical and quantitative studies, supports their faith. Taber et al. (2011) also found that many students compartmentalize science and religion. This could be the case for the candidates in this study; the choice of a quantitative methodology that is based in positivism is compartmentalized from their religious affiliation. Thus, their positivist, quantitative study is unrelated to and compartmentalized from their religion and personal, theistic worldview. In this study candidates who identified with a religious affiliation were just as likely to choose a quantitative dissertation methodology as those who did not.

Overrepresentation of women.

One finding in this study was the much higher number of female candidates completing the Ed.D. program at this university compared to male candidates. There were 257 women and 131 men in the random sample, indicating that the number of women who completed a dissertation as part of the Ed.D. program almost doubled the number of men in the program in the years 2012-2016. Although this is a particularly large gender gap, there is evidence in research that women now represent a majority of college students. According to the National Center for Educational Statistics (U.S. Department of Education, National Center for Education Statistics, 2016b), in 2016, there were 11.7 million female students attending college and only 8.8 million male students. This is a gender-gap reversal from the 1970s, where approximately 58% of all college students were male (Bae, Choy, Geddes, Sable, & Snyder, 2000).

Because this research only involved Ed.D. candidates, women could also be overrepresented in the Ed.D. program because of the higher number of women in the education field. Women make up 76% of teachers (U.S. Department of Education, National Center for Education Statistics, 2015) and 65% of public, K-12 school principals (U.S. Department of Labor, Bureau of Labor Statistics, 2015). According to Perry (2013), women completed 68% of education doctoral degrees. Women also completed 52% of all doctoral degrees in 2012; thus, women are completing more doctoral degrees then men both overall and in the education field (Perry, 2013). The percentage of women completing education doctoral degrees compared to men (68%) is higher than the percentage of women who are K-12 school administrators, but lower than the percentage

of women who are employed as K-12 teachers (76%). Although this study found a higher number of women completing the Ed.D. program, more research is needed to determine why women have shifted to completing doctoral degrees at a higher rate than men; in the 1990s, women completed approximately 49% of all education doctoral degrees (Nelson & Coorough, 1994), which is significantly less than the current 68% (Perry, 2013).

Rise of qualitative research.

The results of this study indicated that the use of qualitative research may be on the rise, just as previous studies have suggested (Nelson & Coorough, 1994). In 1973, only 7% of dissertations utilized a qualitative methodology, and other researchers found in 1980-1993, as low as 3% of dissertations used qualitative research (Nelson & Coorough, 1994; Wick & Dirkes, 1973). In a study that used a sample of Ed.D. dissertations from 1998-2002, Kontorski and Stegman (2006) found that 28.87% of Ed.D. dissertations were qualitative, and similarly, Benson, Chik, Gao, Huang, and Wang (2009) found that 22% of articles published in education journals were qualitative in design between the years 1997 and 2006. Rone (1998) found that qualitative methodologies were increasing and expected them to continue to increase in popularity. Flinders and Richardson (2002) suggested that qualitative research grew so quickly in the 1990s and early 21st century that "it is difficult to find a more prominent trend in the field of education" (p. 1159). It is believed that a change in cultural and political worldviews may be a reason that qualitative research has risen in popularity; the postmodern culture shift has caused more interest in subjective human views, or verbal data, rather than just empirical, positivist studies using numerical data (Alasuutari, 2010; Flinders and Richardson, 2002).

Limitations of the study.

All of the doctoral candidates in this study were from one university. As Kitch and Fonow (2012) found in their study, some schools have a tendency to have a "signature" methodology. Since this study only examined one university's Ed.D. program, it is possible that in this particular university, one methodology may be more encouraged than the other, which would skew the results of this study. Thus, the results of this study may not be generalizable to all Ed.D. programs.

Not all students in this study indicated a religious affiliation. Upon application to the university, students filled out a survey indicating their religious affiliation, and included as options were many different religions, denominations, an "Other" category, and a "None" category. However, many students declined to answer this particular question. The lack of answer of this question could have skewed the sample for religious affiliation in this study. Some students may have felt uncomfortable sharing their affiliation and did not answer, even if they were affiliated with a religion.

CONCLUSIONS

The null hypothesis for this study was not rejected, as there was no significant relationship between dissertation methodology choice and biological sex, ethnicity, age, and religious affiliation. This research contributes to the knowledge base of methodology

choice. Plowman and Smith (2011) provided a study that looked in-depth at the methodology choices of men and women in various professional journals. Although this study contradicts the results of that study, it answers the call for additional research in this area. This study is also the first known study that examines the combination of biological sex, ethnicity, age, and religious affiliation in the context of methodology choice. Although much research has examined these variables regarding mathematics anxiety, attitudes, and achievement, this study is unique in that it examines the combination of these variables in the context of dissertation methodology choice. Using intersectionality as a framework, this study considers the interactions of these dimensions of identity and the relationship that they have on methodology choice. Research that studies intersectionality in relationship to methodology choice is lacking, and this study adds to the knowledge base of intersectionality and the dimensions of identity that affect choices of individuals.

As Flynn, Chasek, Harper, Murphy, and Jorgensen (2012) discussed, the dissertation process is extremely important in doctoral programs. The dissertation allows candidates to become self-directed learners, develops candidates into researchers, and allows for new developments in various fields of study. As Flynn et al. (2012) also noted, the dissertation phase of a doctoral program is where candidates are most at risk of dropping out of the program. The lack of research in the dissertation is problematic, especially considering the importance of the dissertation in doctoral programs. This study adds to the knowledge base of the dissertation process and provides a starting point for other areas that need more research.

The finding of a high number of female students in Ed.D. programs has implications for higher education. This higher-education gender gap reversal has several implications for higher education administration and researchers. As Bae et al. (2000) discussed, the gains of women in education should be celebrated, including their higher rates of persistence, application, and achievement in higher education, but higher education administrators should make it a priority for their programs to attract both men and women and assist both men and women to succeed while completing these programs.

RECOMMENDATIONS FOR FURTHER RESEARCH

There are several areas related to this study where future research is recommended. Because this study only examined dissertations from one university, it would be beneficial for similar studies to be conducted at other universities. In addition, the high number of women in this Ed.D. program and in higher education in general is an area that calls for more research. Studies that focus on men in Ed.D. programs would be beneficial for university administration to understand their motivations for entering the program. In addition, studies focusing on female students and their motivation for completing an Ed.D. program in the context of human capital theory could investigate whether underlying economic reasons exist for the reverse-gender gap.

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Agriculture, Forestry, and Aquaculture

FORMATION OF CHAR-LIKE, FUSED-RING AROMATIC STRUCTURES FROM A NON-PYROGENIC PATHWAY DURING DECOMPOSITION OF WHEAT STRAW. Xi Chen[1], Wenying Chu[2], Jingdong Mao[2] & Hongjian Gao[1], [1]Dept. of Resour. & Environ., AHAU. [2]Dept. of Chem. & Biochem., ODU. Fused-ring aromatics, important skeletal components of black carbon (BC), contribute to long-term carbon (C) sequestration in nature. They have previously been thought to be primarily formed by incomplete combustion of organic materials, and some methods for quantifying pyrogenic C are based on the estimation of fused-ring aromatic C, assuming non-pyrogenic origins are negligible. Using advanced solid-state ^{13}C nuclear magnetic

resonance (NMR), we for the first time identify fused-ring aromatics that formed during the decomposition of wheat (*Triticum* sp.) straw in soil under aerobic, but not anaerobic conditions. The observed formation of polyaromatic units as plant litter decomposes provides direct evidence for humification. Moreover, common methods for estimating pyrogenic BC only by quantifying nonprotonated or fused-ring aromatic C could lead to an overestimation of the contribution of pyrogenic BC to soils. The annual flux of such non-pyrogenic BC could be equivalent to 3-12% of pyrogenic BC added to soils from all other sources. Author contact: x1chen@odu.edu.

THE IMPACT OF FISH HEALTH REGULATIONS ON THE AQUACULTURE INDUSTRY IN VIRGINIA. M. David Crosby, Cooperative Extension. Virginia State University. Many states in the Mid-Atlantic region have fish health regulations requiring fish producers to have fish health paperwork for specific pathogens to ship live fish. Some states, like Virginia, have no regulations and others have strict regulations concerning pathogens like viruses (IPN), parasites (Whirling Disease) and bacterial diseases (Furunculosis). Virginia fish farmers shipping live fish out of state should have fish health inspections. The burden of cost is on fish producers. Most of these regulations are aimed at preventing the introduction of specific pathogens, mostly associated with salmonids, into the state. Private testing can cost about $4000 per farm, and many trout farmers have several farms. To obtain the paperwork needed for shipping fish, a trout producer with four farms would pay $16,000 in testing. This can be the equivalent sales of live fish for one state requiring testing. Koi producers test their fish for spring viremia of carp and herpes carp virus to obtain the fish health paperwork for shipping fish and to maintain a clean facility. Testing trout for gill lice (Salmincola), a recent problem, requires $300-$350 for each shipment into particular states like Pennsylvania. The net result is that fish health regulation is burdensome for small scale trout producers. Larger trout farms are more capable of absorbing this cost. The VSU Fish Health Diagnostic lab has assisted trout and koi producers by testing fish for pathogens required by importing states. The choice for trout farmers is to pass on higher production costs to consumers or go out of business. Author contact: dcrosby@vsu.edu

FUNCTIONAL, STRUCTURAL, AND ANTIOXIDANT PROPERTIES OF CHICKPEA PROTEIN HYDROLYSATES AFFECTED BY ENZYMATIC HYDROLYSIS. Magdalini Galanopoulos, Edward Sismour, Patricia Lynch, Abeer Almutaimi, & Yixiang Xu. Agricultural Research Station, Virginia State University, Petersburg, VA 23806. Chickpea protein isolate (CPI) was hydrolyzed batchwise using Alcalase or Flavourzyme individually or by sequential treatment using Alacase followed by Flavourzyme. Functional, structural and antioxidant properties as well as SDS-PAGE profiles of the hydrolysates were investigated. Alcalase was more effective than Flavourzyme at cleaving peptide bonds, and extensive hydrolysis occurred during sequential treatment. Hydrolysates had a significant ($P<0.05$) increase in the solubility and emulsifying capacity. Fourier-transform infrared spectroscopy showed that ordered secondary structures in original CPI were lost during hydrolysis and new random coil structures were formed. Compared to CPI, all hydrolysates presented significantly ($P<0.05$) higher DPPH• scavenging capacity, especially sequentially-treated hydrolysates. SDS-PAGE banding patterns of the hydrolysates were markedly changed,

especially for hydrolysates treated using Alcalase in which protein bands were not visible. The results reveal that hydrolysis enhanced the functional properties and antioxidant activity of chickpea protein which may be beneficial for potential functional food ingredient application. Funding was provided through the USDA Evans-Allen program. Author contact: Yixiang Xu, yixu@vsu.edu.

DEVELOPMENT OF EUDRAGIT EPO/HPMC/CELLULOSE NANOCRYSTAL-BASED NANOCOMPOSITE TASTE MASKING FILMS. Alexiss McKinney, Shakeyla Willis & Yixiang Xu, Agricultural Research Station, Virginia State University, Petersburg, VA 23806. Taste-masking techniques have been widely utilized to conceal unpleasant tastes of medicines. Film coating has been found to be the most effective and commonly used approach for this purpose. Eudragit EPO, a cationic polymer with a low solubility at neutral pH and high solubility at low pH, is a desirable candidate as a film matrix. The objectives of this study were to (1) prepare Eudragit EPO nanocomposite films by incorporating hydroxypropylmethylcellulose (a co-matrix material), cellulose nanocrystals (CNC, a strengthening agent), and glycerol (a plasticizer) using a solvent cast method, and (2) evaluate disintegration rate, chemical structure, and thermal properties of the produced films. A faster disintegration rate was observed for the films immersed in an acidic environment than those in a neutral condition. Further, increasing Eudragit EPO concentration made disintegration of the films easier in both neutral and acidic conditions. Fourier-transform infrared spectroscopy results indicated that incorporation of CNC did not cause any structural changes because of its solubility, while differential scanning calorimetry results indicated that the glass transition temperature of the films decreased with increasing concentration of Eudragit EPO, which facilitated their disintegration. Our study results support the potential use of Eudragit EPO-based films for taste masking applications. Funding was provided through USDA Capacity Building Grant No. 2013-38821-21124 and Pfizer Consumer Healthcare. Author contact: Yixiang Xu, yixu@vsu.edu.

OVEREXPRESSION OF PODRM2, AN EPIGENETIC REGULATOR FROM PURSALNE, ENHANCES STARCH ACCUMULATION IN *ARABIDOPSIS THALIANA*. David Joseph & Shuxin Ren, Agriculture Research Station, Virginia State University. Starch, a major nutrient in the human diet, is considered key for bio-ethanol production. Starch is produced during photosynthesis by plants. Increasing starch production will help to provide foods for human consumption and animal feedstock, as well as for potential bioenergy production. Previously, we successfully cloned a homolog gene, DRM2, from Purslane and overexpressed PoDRM2 in *Arabidopsis*. Comparing the growth of wild-type Columbia and homozygous PoDRM2 transgenic lines, we observed that the plant size of PoDRM2 lines was significantly larger than that of Columbia, suggesting a potential high efficiency in photosynthesis. To confirm this observation, we investigated starch synthesis/accumulation in leaves using iodine staining. At the end of light period, PoDRM2-carrying *Arabidopsis* lines accumulated significantly more starch than did the control. More strikingly, at the end of dark period, as predicted, the wild-type control did not accumulate starch, whereas PoDRM2 lines accumulated starch as much as during light period. Furthermore, PoDRM2 lines contained more chlorophyll than the control. These results indicate that PoDRM2 functions as a key regulator of starch

accumulation. PoDRM2 encodes a methyltransferase, and genome-wide bisulfite sequencing identified >2,500 genes with altered methylation status. 55 out of 61 genes on the photosynthesis pathway were altered. Our results suggest that DNA methylation plays important role in plants regulating photosynthesis. Author contact: Shuxin Ren, sren@vsu.edu.

Posters

EVALUATION OF CHESAPEAKE BAY BLUE CATFISH (*ICTALURUS FURCATUS*) FOR VALUE-ADDED APPLICATION. Jayjuan Robinson, Mzuna Aldossari, Edward Sismour & Yixiang Xu. Agriculture Research Station, Virginia State University. Blue catfish (*Ictalurus furcatus*, BC), introduced to Chesapeake Bay to enhance sports fishing, and is now consider invasive. BC are estimated to comprise over 70% of fish biomass in the James River and similar conditions likely exist in other Virginia tributaries. Given its high fecundity and abundance, eradication is impossible. Control efforts have focused on increasing consumer awareness and consumption have met limited success. Development of value-added uses for BC meat and processing waste has not been investigated to our knowledge. As an initial step, we are evaluating protein isolated from BC fillets (FPI). Fresh fillets (n=14) were obtained from a local processor. White muscle was composited and divided into 12 portions. Half were extracted fresh and half were extracted after 1 month frozen (-20 °C) storage. For each storage condition, half were extracted using H_2O and half using 0.5M NaCl. The FPI was freeze-dried and used to characterize protein yield, color, emulsification, protein structural composition (amide I). Yield was higher for frozen fillet ($p=0.008$) and did not differ between extraction methods. Color did not differ among dry samples. FPI showed no emulsification capacity. Amide I peak area differed significantly ($p<0.000$) and was highest for fresh, H_2O-extracted FPI and lowest for frozen, NaCl-extracted FPI. This project has been supported by funding from the USDA Evans-Allen program. Author contact: Yixiang Xu, yixu@vsu.edu.

Archeology

MAPPING LANDSCAPES OF RESISTANCE AND FINDING A WAY FORWARD FOR AN ARCHAEOLOGY OF MARRONAGE IN THE GREAT DISMAL SWAMP. Becca Peixotto, American University and Perot Museum of Nature and Science. The Great Dismal Swamp Landscape Study (GDSLS) began in 2001 to investigate archaeologically the resistance communities that thrived in the wooded wetlands in southern Virginia and northern North Carolina between 1610 and 1860. Led by Daniel O. Sayers, the GDSLS focused its efforts in North Carolina on a mesic island miles into the swamp on land now managed by the U.S. Fish and Wildlife Service. Excavations there and elsewhere demonstrated that marginalized peoples, including indigenous Americans and African and African American Maroons, maintained a continuous presence in the swamp, operating both within the bounds of colonialist expansion and enslavement and beyond their control. A 2013 LiDAR survey revealed dozens of potential islands scattered throughout the swamp and revitalized exploration

and site-discovery efforts. One of these offshoots, the Swampscapes project led by the author, identified a viable method for surveying large swaths of the swamp and discovered two new Maroon-associated sites and several high-potential locations. This presentation summarizes the findings of nearly 20 years of fieldwork by the GDSLS team, and suggests avenues for future research aimed at a more thorough understanding of the landscapes, lifeways, and lives of the Dismal Swamp Maroons. (Swampscapes research supported by the Archeological Society of Virginia, The Explorers Club Washington Group, WINGS WorldQuest, and American University). Author contact: Becca Peixotto, becca.peixotto@american.edu.

A SURVEY OF VIRGINIA'S DUGOUT CANOES. H. Robert Hayes, Maritime Heritage Chapter, Archeological Society of Virginia. The practical and economic importance of single-log dugout and multi-log built canoes for Native Americans and European settlers is well established. In Virginia, the Mid-Atlantic Dugout Canoe/Logboat Registry currently has documented 27 of these vessels from 14 counties and two independent cities (Poquoson and Suffolk). Of these, 20 are single dugouts and seven are of multi-log construction. Twelve are recorded in the Virginia Department of Historic Resources' Virginia Cultural Resources Information System (VCRIS). For all vessels, significant data gaps exist, such as: physical measurements, wood type, tools used, methods of construction, and time-period dating. All 27 vessels show signs of post-contact-period construction. For some single-dugout canoes only written records remain, with the final disposition of the canoe unknown. Where determined, pine (yellow and loblolly), cypress, and chestnut logs were used for construction. Single-dugout canoes range in length from 11 to 26 feet (avg.16 feet). Multi-log boats range from 15 to 51 feet, and these appear to be correlated to time period, use, and the number of logs used for construction. The Registry team believes that there are several more canoes and logboats to be found and documented in Virginia; active field efforts to find them in creeks, rivers, and lakes, as well as continued investigation of private and museum collections and archives, will continue. (Supported by: Institute of Nautical Archaeology, and Archeological Society of Virginia). Author contact: Robert Hayes, asvcanoe@gmail.com.

THE EVOLUTION OF GLOUCESTER'S PLANTATION LANDSCAPES. Thane Harpole, The Fairfield Foundation. Major plantations such as Fairfield, Rosewell, and Warner Hall dominated Gloucester County during the Colonial and Antebellum periods. The families who owned these properties were prominently placed politically, socially, and economically within Virginia's governing class, and they controlled large numbers of enslaved Africans whose labor dramatically transformed the natural landscape. However, little survives in the documentary record to chart the creation and alteration of a complex cultural landscape from the mid-17th to mid-19th centuries. The use of both large-scale archaeological survey and focused test excavation at several prominent properties across the county is beginning to detail the scope and scale of these plantation landscapes and reveal in-depth information about the lives and interactions of the people who lived in these spaces. Author contact: Thane Harpole, thane@fairfieldfoundation.org.

DEVELOPING AN INTERACTIVE MODEL OF ARCHAEOLOGY AT FAIRFIELD PLANTATION WITH PHOTOGRAMMETRY AND 3D PRINTING. Ashley McCuistion, The Fairfield Foundation. Fairfield Foundation archaeologists initiated the Fairfield Model project in 2017. The goal of the project is to create an interactive three-dimensional (3D) model of archaeology at Fairfield Plantation, a 17th-century archaeological site in Gloucester County, Virginia. To create the model, we use a Phantom 4 Pro drone to photograph the base of each layer of soil we excavate, then process the images through Agisoft Metashape photogrammetry software to produce 3D models. The models are transformed into solid objects in Autodesk 3ds Max and printed at a 1:30 scale using a MakerBot Replicator+ 3D printer. Each printed component is an exact representation of a five-foot-square test unit layer, and each layer fits seamlessly on top of the layer below. The interactive model simulates the process of archaeology by allowing users to "excavate" the site and discover its history using archaeological methods. It has proven to be an effective teaching tool in classrooms and at the Fairfield Foundation's Center for Archaeology, Preservation and Education. Author contact: Ashley McCuistion, ashley@fairfieldfoundation.org.

ARCHAEOLOGY WITHOUT (GOOD) STRATIGRAPHY: WHAT WE CAN LEARN FROM COMPRESSED MOUNTAIN SITES. Carole L. Nash, School of Integrated Science, James Madison Univ. Multi-component archaeological sites in mountain settings are subjected to processes of extensive weathering and erosion, resulting in net deflation over time and a concentration of weather-resistant artifacts and natural rocks within near-surface contexts. In addition, the shallow profiles of compressed O/A and E/B soil horizons are subjected to various biogenic and cultural disturbances over millennia (tree roots, frost heave, burrowing, plowing, etc.). Together, these processes can contribute to an apparent lack of easily discernable vertical cultural stratigraphy, which removes the temporal framework necessary for evaluating findings. A recent excavation of Virginia Blue Ridge sites with cultural components dating from the Early Archaic through Late Woodland periods demonstrates that, despite the presence of lagged, mixed surfaces, it is possible to identify spatially discrete activity areas through the horizontal distribution of artifacts. The patterning of diagnostic artifacts in these areas allows for general statements regarding re-occupation across millennia. Archaeologists working in mountainous settings are encouraged to consider the possibility that compressed site conditions may require new approaches to data analysis and a shift in the kinds of research questions asked of the archaeological record. (Supported by the National Park Service and the Shenandoah National Park Trust). Author contact: Carole Nash, nashcl@jmu.edu.

DISCOVERY THROUGH REHABILITATION: THE BETTY VEATCH POTOMAC CREEK COLLECTION. Erin M. Cagney, New South Associates, Veterans Curation Program. In 2017, archaeologists at American University rediscovered the Betty Veatch collection sitting forgotten on the lab shelves—boxes upon boxes of prehistoric and historic artifacts alongside Veatch's personal journals, field logs, and photographs. After undertaking an emergency rehousing of the at-risk collection, it became apparent that the Betty Veatch collection was rich with recoverable and significant data from more than 54 sites in the Potomac Creek estuary in Virginia. The

estuary has been occupied for thousands of years and most famously was the location of the Patawomeke village, a contact-period, palisaded settlement known to archaeologists as the Indian Point site or 44ST01. Though several notable early archaeologists visited and collected artifacts from Indian Point, the location of those artifacts is unknown, and no systematic archaeological excavation ever has been conducted. Now the site has eroded into the Potomac River and the little that was left was graded away by the property owner in the 1980s. Veatch's collection contains hundreds of artifacts from 44ST01, enabling the first-ever cataloging and analysis of artifacts from the site. The artifacts reveal a long period of occupation in the Potomac Creek estuary and a diverse array of highly specialized tools and vessels. This analysis of Indian Point sheds new light on the village of Patawomeke and clearly illustrates the importance of maintaining and curating orphaned archaeological collections, particularly those from sites threatened by erosion and sea level rise. (Supported by: Council of Virginia Archaeologists, Virginia Department of Historic Resources, and Archeological Society of Virginia Northern Virginia Chapter). Author contact: Erin Cagney, erincagney@gmail.com.

DENDROCHRONOLOGY OF ATLANTIC WHITE CEDAR (*CHAMAECYPARIS THYOIDES* (L.) BRITTON, STERNS & POGGENB): IMPLICATIONS FOR COLONIAL WOODCRAFT. James M. Doyle & Robert B. Atkinson, Dept. of Organismal and Environmental Biol., Christopher Newport Univ. Atlantic white cedar (*Chamaecyparis thyoides*), AWC, occurs on coastal peat swamps from Mississippi to Maine. Commercial uses of the wood contributed to early over-harvest, which was said to have made the species endangered in New England by 1748. Wood from the species is lightweight and resists decay, traits valued for shingles, siding, buckets, and boatbuilding. Narrow tree ring widths, termed "tight grain" by wood crafters, makes the species easy to work and further enhances its rot resistance. Our results suggest that seasonally flooded saturated hydrologic regimes of natural peatlands were pervasive during the colonial era and favored narrow rings. However, the advent of ditching and draining of peatlands caused faster growth rates. Moreover, drained peat no longer favored AWC over competitors such as red maple (*Acer rubrum*), drained peat was more combustible, and post-drainage peat fires prevented natural regeneration and exacerbated shortages. Initial surveys of Colonial Williamsburg roofing materials seem to suggest that a decline in AWC caused people to favor bald cypress (*Taxodium distichum*) for shingles. Author contact: James Doyle, james.doyle.15@cnu.edu.

SEA LEVEL RISE AND THE LOSS OF ARCHAEOLOGICAL RESOURCES: TIME AND TIDE WAIT FOR NO MAN. Michael B. Barber, Archeological Society of Virginia. Archaeological resources along Virginia's Chesapeake Bay and Atlantic Coast shorelines are being threatened more than ever by sea level rise, catastrophic storm surge, and tidal erosion. As climate change is taking its toll, archaeologists can no longer afford to stand idly by and watch the devastating loss of significant data. Nor can we continue to adhere to the time-honored concept of "preservation in place" as the place will soon be the bottom of the sea or bay. Archaeologists also are faced with the disturbing reality of excavating without writing reports as time spent in report documentation will result in the loss of data. Examples of preservation efforts will be

presented along with a proposed action plan. Author contact: Michael Barber, archaeova@gmail.com.

ANALYSIS OF EUROPEAN AND DOMESTIC TOBACCO PIPES RECOVERED FROM EYREVILLE, SITE 44NH0507, IN NORTHAMPTON COUNTY, VIRGINIA. Michael Clem & Michael Barber, Virginia Department of Historic Resources. Following five excavation sessions, each lasting approximately ten days, we have recovered some 1,878 tobacco pipe stems, bowls, and fragments. Of those, 1,047 were made of white ball clay manufactured in both England and Holland. Also recovered were 831 red clay pipe fragments of local manufacture. Of the European pipe stems that were dated using bore diameter size as the methodology, slightly more than 50% date to the decades prior to 1650 and only 8% date to after the end of the 17th century. Of the white stems, only 64 were decorated with a floral or "fleur-de-lis" design, indicating Dutch origins. Of the 331 red clay bowls and bowl fragments, 261 were decorated with various zoomorphic and geomorphic designs, with the "running deer" motif dominating. The running deer pipe bowls display a great variety of artistic styles, which may indicate multiple artisans. The dominance of 17th century pipes raises questions concerning the known 18th century occupation of the site. In addition, questions arise regarding trade networks with both European and local markets. It appears as though trade with Dutch merchants may have dwindled following the Navigation Acts (1651, 1660) and that smoking among the occupants of the site starts to diminish in the last decades of the 17th century. It also appears, as with many other Chesapeake region sites, that local pipe manufacture and usage terminate by the end of the 1600s. Author contact: Michael Clem, mike.clem@dhr.virginia.gov.

RITUALIZED PRACTICES OF THE PRECOLONIAL CHESAPEAKE: AN EXAMINATION OF THE HATCH SITE (44PG51). Michael Makin, Virginia Department of Historic Resources. Excavated in the 1970s and 80s by Lefty Gregory, the Hatch site in Prince George County is arguably among the most significant precolonial archaeology sites in the Commonwealth of Virginia. Though the collection sat in storage for decades, it was recently donated to the Virginia Department of Historic Resources, making it accessible to researchers. The thorough excavation combined with abundant radiocarbon data allow the historical narrative of this magnificent site to come into focus. An unusual place, hidden in a remote location, the Hatch site witnessed frequently occurring ritualized gatherings from 900 to 1400 CE. These gatherings involved the sacrifice and internment of dogs as well as elaborate feasts on both estuarine and terrestrial resources. The ceremonies appear to have concluded with termination rites in which materials associated with the ritual were left in place where the event occurred. This presentation provides an overview of my interpretation of the Hatch site and explores the site's place within the broader precolonial context. Author contact: Michael Makin, dmmakin@email.wm.edu.

FINDING RICHMOND'S FIRST AFRICAN BURIAL GROUND: A HISTORICAL AND ARCHAEOLOGICAL ANALYSIS. Bryan Clark Green, Commonwealth Architects & Matthew R. Laird, The James River Institute for Archaeology, Inc. Until the City of Richmond established a new public cemetery for both enslaved and free

African Americans in 1816, its black residents were interred in the "Burial Ground for Negroes," a cramped and flood-prone cemetery in the Shockoe Bottom district. Despite its importance in the history of Richmond's African American community, virtually no documentary or cartographic evidence of the cemetery has survived. This absence of information has led to considerable speculation about when it was established, how large it was, and exactly where it was located. However, a painstaking analysis of newly uncovered sources has revealed how and when the cemetery came to be, and it is now possible to situate it within today's vastly altered urban landscape. This fuller understanding of the African Burial Ground has important implications for archaeologists, historians, preservationists, and the community at large. Neglected and disturbed since the early nineteenth century, the cemetery embodies how the city's distinctly African American spaces have been consistently devalued. In recent years, the African Burial Ground has become a touchstone in the debate between advocates of development and preservation in Shockoe Bottom. A clearer understanding of the cemetery, as well as its historical and physical contexts, can help Richmond to acknowledge and memorialize the lives and deaths of its earliest African American residents in an informed, meaningful, and lasting way. Author contact: Bryan Green, bryancgreen@gmail.com.

WHEN THE WATERS RISE: BURIALS AND FUNERARY OBJECTS FROM THE UPPARDS CEMETERY (44AC0571), TANGIER ISLAND, ACCOMACK COUNTY, VIRGINIA. Joanna Wilson Green, Virginia Department of Historic Resources. Over several days in December 2012 and April 2013, archaeologists from the Virginia Department of Historic Resources recovered a series of late-19th- and early-20th-century burials from the long-abandoned Tangier Island community of Canaan, located at the tip of the island in an area known as the Uppards. This northernmost portion of the island was heavily damaged by storm surge-related erosion, resulting in the exposure of human remains and coffin hardware along the beach. Storm and tidal action also displaced headstones from their intended graves, rendering identification of the interred individuals difficult if not impossible. In the absence of this information, we turned to analysis of the remains themselves as well as the items with (and within which) they were buried, using this information to build a context for the burials. This presentation focuses upon the results of both anthropological and material culture analysis, presenting these results as well as the inferences that may be made about these individuals and the now-lost community of Canaan. Author contact: Joanna Green, joanna.wilson@dhr.virginia.gov.

Astronomy, Mathematics and Physics with Material Sciences

GUESSTIMATION: SOLVING THE WORLD'S PROBLEMS ON THE BACK OF A COCKTAIL NAPKIN. Lawrence Weinstein, Old Dominion University. Why don't we all drive electric cars? Does it really matter if you don't recycle that plastic water bottle? If the Sun were made of gerbils, would the Earth be incinerated? How can we answer these questions without relying on experts? This talk will cover the principles of estimating, introduce the "Goldilocks" categories of answers, and then look at some of

the big (and small) questions of our time, including: Should we ban plastic straws? Gasoline or electric cars? Should we pee before flying? Author contact: Lawrence Weinstein, weinstein@odu.edu

THE EFFECTS OF RADIO WAVES WITH THE NERVOUS SYSTEM. Alexandria E Federick & Giovanna Scarel, Physics Dept., James Madison Univ. The interaction of electromagnetic waves with matter, and the sensitivity of capacitors to electromagnetic waves, is the fundamental reason for our research [1]. In this research, we wanted to understand how radio waves effect the Nervous System, through various parts of the human and animal body. Indeed, the Nervous System is a complex electric system made of capacitors. We observed that conservation of energy describes the interaction with the Nervous System of electromagnetic waves down to radio waves. For this part of the work we have used literature data.[1] Boone,D.E., Jackson, C.H., Swecker, A.T., Hergenrater, J.S., Wenger, K.S., Kokhan, O., Terzić, B., Melnikov,I., Ivanov, I.N., Stevens, E.C., and Scarel, G. (2018) Probing the Wave Nature of Light-Matter Interaction. *World Journal of Condensed Matter Physics*, 8, 62-89. Author contact: federiae@dukes.jmu.edu.

CUBIC NONLINEARITY OF TUNGSTEN DISULFIDE NANOFLAKES THROUGH RESONANT EXCITATION. Tikaram Neupane, Dulitha Jayakodige, Sheng Yu, Bagher Tabibi, and Felix Jaetae Seo, Advanced Center for Laser Science and Spectroscopy, and Center for Atmospheric Research and Education, Department of Physics, Hampton University, Hampton, VA 23668. The cubic nonlinearity of optical materials has been articulated for the optoelectronic applications of Q-switch, mode-locking, optical power limiting, and optical modulator. Tungsten disulfide atomic (WS_2) layer is an intriguing nonlinear optical material due to the exotic materials and optoelectronic properties in atomic-scale flatland with the intralayer covalent bonding and interlayer van der Waals interactions. The cubic nonlinearities of WS_2 includes ~1-4 atomic layers in aqueous solution were characterized using a Z-scan techniques with the nanosecond pulse excitation source of ~ 532 nm. The WS_2 nanoflakes were resonantly excited at the absorption spectral region between A and B exciton peaks. The probability rate of direct transition in monolayer is relatively higher than that of indirect transition in bi/multi atomic layers. In addition, the higher laser intensity could excite the charge carriers into the deeper conduction band through a two-step transition. The open and closed Z-scan revealed the positive nonlinear absorption (~ 6.2 $\times 10^{-8}$ m/W) with reverse saturation, and the negative nonlinear refraction (~ -3.8 $\times 10^{-15}$ m^2/W) with peak-valley nonlinear transmittance respectively. The reverse saturation absorption indicates that the ground state absorption is larger than the excited state absorption, and the peak-valley trace indicates the defocusing characteristics. Acknowledgment: This work is supported by ARO W911NF-15-1-0535, NSF HRD-1137747, and NASA NNX15AQ03A. Corresponding Author: jaetae.seo@hampton.edu

IS THE GRASS REALLY GREENER ON THE OTHER SIDE? (IS THE FISHING REALLY BETTER IN THE OTHER RIVER?) Tom Mosca III, Rappahannock Community College. Fishery independent data collected by the Virginia Institute of Marine Science Trawl Survey from 1955 until 1995 were analyzed using one-

way ANOVA and Tukey *post hoc* analysis. The variable under consideration was catch per unit effort (number of each species per minute of trawl), and the three levels of analysis were James, York and Rappahannock Rivers. Analyses were performed for 14 species of finfish and blue crab, in order to identify relative abundance of each species in each river, as compared to the other two rivers. The idea was spawned by the widely held but anecdotal belief that large "yellow bellied" spot are more prevalent in the Rappahannock River than in the other two. Spot are in fact more abundant in the Rappahannock River, as are white perch, while there are significantly fewer hogchoker and blackcheek toungefish (both inedible) than in the other rivers. More Atlantic croaker, weakfish, silver perch, and white catfish were found in the York River. The James held more hogchoker and bay anchovy (both inedible), and channel catfish. Results for other species were mixed. Author contact: Tom Mosca III, tmosca@rappahannock.edu

FINDING MINOR PLANET PLUTO USING "BLINKING" SEVERAL IMAGES TAKEN TWO DAYS APART. Abraham J. Goldstein, Information Technology Department, Tidewater Community College. The author used software from a remote telescope located in the Canary Islands to image the minor planet Pluto. The site is known as the SLOOH Telescope site. Currently, the site has several telescopes positioned in Chile and the Canary Islands. The SLOOH images were all taken from the same telescope (alternatively, on odd and even days, two days apart). One could not distinguish the minor planet Pluto from these images by viewing only one image. However, by using the technique of "blinking" (superimposing common star patterns found in each image), one quickly finds that one image seems to "jump" when compared to hundreds of stars in the other image. This jumping image is the minor planet Pluto. Without using this technique, it would not be possible to differentiate Pluto from the neighboring stars in the same field. This blinking technique has also been used by astronomers to find asteroids, comets, and other minor planets in our solar system. Therefore, this well-known system has been used successfully both manually (as presented) and electronically in software applications to find previously undiscovered bodies. Author contact: JGoldstein@tcc.edu.

Posters

FABRICATION OF A COSMIC RAY VETO SYSTEM FOR THE MU2E EXPERIMENT. Kyle R. Fielman, Dept of Phys., University of Virginia. The Mu2e experiment will search for unambiguous evidence of charged lepton flavor violation through observation of the decay $N\mu^- \rightarrow N e^-$. In a three-year run, a single-event sensitivity of 2.9×10^{-17} is expected, 10,000 times better than the current limit. In order to keep the background below 0.25 events over the course of the run, an overall veto efficiency of 99.99% must be achieved. The Cosmic Ray Veto (CRV) is designed to meet these requirements with a dead time of approximately 5%. The CRV consists of extruded planks of polystyrene coated with titanium dioxide. The two extrusions house wavelength shifting fibers that transport photons to the end of the counters. Two counters are glued together to form the fundamental component of the CRV, the di-counter. Fiber guide bars are attached to the end of these di-counters to ensure alignment with the Silicon

photomultipliers used to detect the signal. Each of these di-counters is put through image testing, transmission testing, and testing with a radioactive source. The proficient di-counters are used to make modules which consist of four layers of di-counters interspersed with aluminum sheets. Currently, 1007 of the 2736 di-counters have been produced, along with the first five modules. Results from a test beam used on a pre-production batch indicates that the counters yield 42 PE/cm, far above the necessary 25 PE/cm. Author contact: krf4fe@virginia.edu.

Biology with Microbiology and Molecular Biology

CHARACTERIZATION OF PH-RESPONSIVE GENES IN *CRYPTOCOCCUS NEOFORMANS*. Kristen I. John[1], J. Andrew Alspaugh[2] & Michael S. Price[1,2], [1]Dept. of Biology & Chemistry, Liberty University and [2]Dept. of Medicine, Duke University. Compared to other fungal pathogens, *Cryptococcus neoformans* is particularly skilled at adapting to the human host environment in order to avoid detection by the immune response. One of the primary ways in which it does this is through its pH regulation system of the Rim pathway. Four genes were recently shown to be related to pH regulation within C. neoformans – CNAG_01580, CNAG_02291, CNAG_05866, and CNAG_06473. In order to characterize the function of these genes, we created knockout mutations by PCR and biolistics transformation. Through phenotypic screening, we identified mutant strains that were defective at growth at an alkaline pH. If these genes display a significant role in virulence, they may be potential targets for therapy in the future. (Supported by: Undergraduate Research Grant, The Virginia Academy of Science, and Provost Research Initiative Grant, Liberty University). Author contact: Kristen John, kjohn1@liberty.edu.

MONITORING THE STABILITY OF TRANSGENES IN *THERMOSYNECHOCCUS ELONGATUS* BP1. Cherrelle L. Barnes, James W. Lee & Lesley H. Greene. Dept. of Chemistry and Biochemistry, Old Dominion University. Genetically engineered (GE) cyanobacteria have become a platform for renewable energy production, in that biofuels can be produced from CO_2, water and sunlight by introducing a set of genes. Although the synthetic biology approach seems advantageous, it is important to understand the bio-risk of these organisms if they were to be used for commercial application. One of these possible bio-risk concerns is the stability of transgenes within such GE organisms if they were to escape into the environment. In this study, genes of interest were inserted into the chromosome of *Thermosynechococcus elongatus* BP1 via of homologous recombination. Once the transformation and insertion of genes were verified by PCR, sets of cultures were prepared with and without antibiotic pressure for an extended period-of-time. Over a 6-month period, the presence of the transgenes was tested every two weeks by PCR. The expression of the transgene was also tested by reverse-transcription PCR. The results of this study will be presented. Understanding how long transgenes remain in the chromosome of the host can be valuable to the biotechnology community that are considering using the GE cyanobacteria approach for biofuel production and policy makers that want to safely

regulate many GE organisms for commercial production. Author contact: clbarnes@odu.edu.

DETERMINING THE ROLE OF A *SACCHAROMYCES CEREVISIAE* GENE, YDL199C, IN DNA REPAIR. Mariam Tekle & Deborah Zies, Dept. of Biol., University of Mary Washington. Genomic DNA carries the genetic information in all organisms, therefore it is essential to preserve its integrity. If the genetic information is compromised then mutations can arise, leading to many potential problems, including cancer. All organisms must constantly monitor their DNA for damage and have mechanisms by which they can repair damage. While the main DNA repair genes have been well characterized, there are still likely to be many genes that contribute to successful DNA repair. Our goal is to use budding yeast as a model organism for the identification of novel genes involved in DNA repair. We chose a gene of interest, YDL199C, from a large-scale study conducted by Jaehnig et al (1). The researchers treated wild-type yeast cells with a mutagen, methyl methanesulfonate (MMS) and identified genes that changed in expression. To confirm the result for our gene of interest, we treated wild type strains with MMS over-time and measured target gene expression using qPCR. Results to date show that there is high variability in both our gene of interest, YDL199C and our positive control, MAG1. Due to the high variability, we cannot refute or approve the original findings. To further investigate the function of our gene, we compared a strain deleted for YDL199C to the wild type strain in budding index, drug sensitivity and mutation rate assays. The budding index results suggest that the deletion strain does not have a cell cycle phenotype. The drug sensitivity assay showed that there is no difference between the two strains and the mutation rate assay showed that there is no significant difference between the wild-type and the strain deleted for, YDL199C. (Supported by: Irene Piscopo Rodgers '59 and James D. Rodgers Student Fellowship II and UMW Undergraduate Research). Author contact: mtekle@mail.umw.edu

DEGRADATION OF POLYETHYLENE TEREPHTHALATE PLASTIC BY IDEONELLA SAKAIENSIS - PART I. Todd D. Gruber, Caroline Tsui & Andrew C. Chafin, Department of Molecular Biology and Chemistry, Christopher Newport University. PETase is an enzyme that degrades the plastic found in plastic water bottles (polyethylene terephthalate – PET). We have cloned the PETase enzyme into an expression plasmid under an inducible promoter for use in *E. coli*, and developed assays to measure rates of plastic degradation by this enzyme. We can detect enzymatic activity via a colorimetric assay using p-nitrophenyl acetate (PNPA), a small molecule substrate analog. This assay is straightforward, easy, and fast. Additionally, we have found that *Ideonella sakaiensis*, the bacterium from which PETase was cloned, can only be grown on certain types of PET. Specifically, the degree of plastic crystallinity has a significant impact on growth. We demonstrate that by changing the crystallinity of a particular plastic sample, we can change a sample that does not support growth into one which robustly supports growth. Finally, we have developed an assay in which plastic degradation can be monitored spectroscopically, allowing us to begin to select for improved mutants of the parent organism. Supported by a Small Project Research Grant from VAS 2018. Author contact: todd.gruber@cnu.edu.

INVESTIGATING PHENOTYPIC DIFFERENCES BETWEEN THE STP1 K/O AND WT *ARABIDOPSIS THALIANA* IN RESPONSE TO VARIOUS ENVIRONMENTAL STRESSES. Aya Andos, Ani Clem, Alexis Foor, Catherine Shola, & Janet Daniel, James Madison University. Sugar transport protein-1 (STP-1) is an H+/monosaccharide co-transporter in model organism *Arabidopsis thaliana*. We are investigating this protein because its impacts on the growth and function of the plant are not well known. For a better understanding of how STP-1 contributes to this plant, we are growing wild type (WT) and STP-1 knock-out (k/o) plants on agar plates to measure their responses to different environmental stressors. Previous work in the lab show that STP-1k/o seedlings grown on agar plates containing 50 -100mM NaCl have increased root length, stalk length and more leaves at 4 weeks. These results suggest that STP1 k/o influences plant osmoregulation. Over the last year, we have been characterizing the halotropic response of WT and STP-1 k/o plants by plating seeds on 0mM/300mM split plates to determine genotype specific response to salt exposure. In addition to characterizing the halotropic response we are also measuring root length and the angle of displacement from gravitropic response. Because the hypersaline environment decreases plant growth, we have decreased the salinity to 0mM/200mM split plates to allow roots to grow long enough to observe phenotypic differences. We are also developing methods to increase the harvest of roots, shoots and leaf tissue for tissue-specific gene expression studies. These studies will enable us to better understand the role of STP-1 in the plant. We also plan to extend these studies to compare the gene expression patterns of both genotypes in high saline environment. We were grant winners from the 2018 VAS meeting. Author contact: foorat@dukes.jmu.edu

CIRCADIAN REGULATION OF THE p53 RESPONSE IN CANCER THERAPEUTICS. Esther L. Wisdom, Xianlin Zou, Sarah K. Jachim, Philip Stauffer, Anne M. Brown, Liang Jiang, & Carla V. Finkielstein, Dept. Biol., Virginia Tech. The p53 tumor suppressor transcriptionally regulates cell cycle progression and death processes in response to genotoxic stress and thus prevents the accumulation of mutations and cancer development. Mutants of p53 that are transcriptionally inactive as result of structural rearrangements can be rescued by drug treatment. One mutant that shows promise for this approach contains a Tyr to Cys mutation (named p53YC hereafter) causing a destabilizing crevice. Due this crevice, p53YC is largely unfolded at body temperature and doesn't trigger cell cycle arrest or apoptotic pathways. Aminobenzothiazole derivatives can bind to the destabilizing crevice. The crevice sits at the interface of binding with PER2 a circadian protein that regulates p53 stability, activity, and shuttling between cellular compartments. This led us to hypothesize that treatment with aminobenzothiazole derivatives would be more effective if delivered at a time-of-day when PER2 expression in the tumor is low. First, we looked at the effect of different mutations in p53 and PER2 on their binding. The YC mutant showed increased binding to PER2 and mutants near the YC crevice showed a variety of binding affinities. We monitored the effect of drugs on p53 and PER2 binding using immunoprecipitation and docking modeling. Higher concentrations of aminobenzothiazole reduced PER2 and p53 binding. We also monitored the circadian expression and stability of PER2 and p53 in the presence of aminobenzothiazole. Our findings place PER2 as a direct regulator of

p53 and provide insights on PER2's relevance in cancer therapeutics. Author contact: elwisdom@vt.edu

PATTERNS OF WHEEL RUNNING IN BULBECTOMIZED MICE. Anna M. Rinko. & Robert P. Waters, Dept. of Biol., University of Mary Washington. This work aims to better characterize the hyperlocomotor phenotype of olfactory bulbectomized (OBX) mice, a premiere model of depression. Characteristics of OBX mice mimic symptoms of human depression and include anhedonia, anxiety, hyperactivity, and hormonal changes. We previously examined anhedonia in this model by providing OBX mice with a reinforcing stimulus in the form of a running wheel, anticipating that these mice would have decreased wheel interaction due to a documented attenuated interest in rewards. Instead, the OBX mice ran significantly more than controls. We concluded that this likely resulted from OBX hyperactivity. To better characterize these findings, we utilized a sorter system that required an operant task to gain access to an external running wheel for a period of three weeks. We also evaluated social dominance and corticosterone levels. We found that OBX mice spent significantly less time interacting with the running wheel, showed disruptions to their circadian pattern of activity, and had higher fecal corticosterone levels at day 21 of the experiment. However, we observed no differences between running speed or entries into the wheel cage. Cage entries increased slightly ($p = 0.182$) among OBX mice. We interpret these changes in wheel engagement as anhedonia, while the increased cage entries reflect hyperactivity in OBX mice. We also provide supporting evidence for circadian disruptions and the presence of higher corticosterone in OBX mice. (Supported by an undergraduate research grant from the University of Mary Washington). Author contact: arinko@mail.umw.edu.

SUCCINATE DEHYDROGENASE ACTIVITY ASSAY DEVELOPMENT AND POTENTIAL EFFECTS FROM A POST-TRANSLATIONAL MODIFICATION. Abigail Vickers, Nhat Truong & Pei Zhang, Department of Biology & Chemistry, Liberty University. O-GlcNAcylation is a post-translational modification that regulates the function of many different proteins. The modification is performed by O-GlcNAc transferase (OGT), which transfers a N-acetylglucosamine onto a serine or threonine residue of the protein. O-GlcNAcylation acts as both a nutrient and stress sensor, increasing in response to elevated glucose levels, nutrient starvation, heat shock, and other stress conditions. Increased O-GlcNAcylation has been linked to cancer and metabolic diseases such as diabetes and obesity, as well as decreased mitochondrial function. Preliminary studies have shown that succinate dehydrogenase (SDH), which acts as both complex II in the mitochondrial electron transport chain and an enzyme in the TCA cycle, is O-GlcNAcylated. SDHA was mutated at predicted key O-GlcNAcylation sites to prevent post-translational modification and was then transfected into Hela cells. Cell lysate was then used to perform an enzymatic assay to determine the effects of O-GlcNAcylation on the activity of SDH. The activity of the mutated SDH was decreased compared to the wildtype, suggesting that O-GlcNAcylation is important to the activity of SDH. Author contact: Abigail Vickers, ahvickers@liberty.edu

Posters

DOES RELB CONTRIBUTE TO TUMOR PROGRESSION IN GLIOBLASTOMA MULTIFORME? H. F. Angel[1], L. N. Brown[2], D. D. Biswas[2], K. A. Mockenhaupt[2], M. G. Marone[2] & T. K. Kordula[2], Thomas Nelson Community College and Department of Biochemistry & Molecular Biology, Virginia Commonwealth University. Glioblastoma Multiforme (GBM) is a vastly aggressive grade IV cancer. Even with the best treatments, the survival of patients with GBM ranges between 12-15 months. GBM is characterized by increased neuroinflammation, with extensive infiltration by residential microglia and high numbers of glioblastoma associated macrophages (GAMs). RelB, a transcription factor and member of the NF-κB pathway, is a marker of mesenchymal GBM and correlates with poor prognosis in GBM patients. Interestingly, we found that RelB induces the activation of GAMs in GBM. Thus, we hypothesize that RelB contributes to the aggressiveness and increased inflammation associated with GBM. To investigate the role of RelB in GBM, we generated spontaneous tumors using an oncogenic lentivirus in wild-type and astrocyte-specific RelB conditional knockout ($RelB^{\Delta AST}$) mice. Histological assessment revealed that tumors were significantly smaller in $RelB^{\Delta AST}$ mice. Additionally, immunofluorescence staining suggested that tumors in $RelB^{\Delta AST}$ mice contain less endothelial cells and decreased vascularization. Further, fluorescence-activated flow cytometry revealed that the number of microglia and macrophages were significantly lower in RelB-deficient tumors, suggesting that RelB plays an important role in GBM-associated neuroinflammation. Together, these data demonstrate that astrocyte-specific RelB plays a crucial role in tumor progression, tumor vascularization, and GBM-associated GAM infiltration. Our results indicate that RelB could be a contributor to the aggressiveness of GBM, suggesting that targeting RelB may lead to novel therapeutics for the treatment of GBM. (Supported by NIH, VCU Bridges to the Baccalaureate R25GM102795). Author contact: tomasz.kordula@vcuhealth.org.

COMBINED EFFECTS OF STATINS AND CHEMOTHERAPY ON HEAD AND NECK SQUAMOUS CELL CARCINOMA. Sara Fioretti & Rosemary Barra, Dept. of Biological Sciences, University of Mary Washington, Fredericksburg, VA. Worldwide, head and neck squamous cell carcinoma (HNSCC) is the sixth most common cause of cancer with a five-year survival rate of 40-50%. Common treatments include various chemotherapeutic agents and radiation, however only 50% of patients respond to conventional treatments. The high morbidity and mortality rates come from the malignant nature of HNSCC. The overexpression of RhoC GTPase, involved in cell signaling, gene expression, cytoskeleton organization, and cell proliferation, mediates HNSCC metastasis. For RhoC GTPase to function, it must be prenylated to form an association with the cell membrane by HMG-CoA reductase. This enzyme is also involved in the synthesis of cholesterol and is inhibited with the commonly prescribed high cholesterol drug Atorvastatin. Previous studies have shown that inhibiting RhoC GTPase prenylation with Atorvastatin limits HNSCC cells metastatic capability. The purpose of this study is to analyze the effect of statins on the effectiveness of the chemotherapeutic agent cisplatin. SCC15 cells were treated with various concentrations of cisplatin and Atorvastatin and cell viability was determined using the MTT assay. Preliminary results indicate a significant dose dependent decrease in cell viability with Cisplatin and Atorvastatin treatment. 40 mM Cisplatin decreased cell viability 72% and treatment with 10 mM Atorvastatin caused a 35% decrease in viability. Combination treatments

appeared to act synergistically, showing a further decrease in SCC15 cell viability. Author contact: rbarra@umw.edu.

HUMAN TUMOR XENOGRAFTS IN *XENOPUS* FROGS. Estefanie M. Marshall[1], Santiago Lima[2] & Amanda J. Dickinson[2], Thomas Nelson Community College and Department of Biology, Virginia Commonwealth University. *Xenograft models* are an important tool to study the development and progress of cancers. They allow us to test new drugs and examine mechanisms underlying the growth or death of cancer cells. In particular, aquatic models such as zebrafish larvae are being explored as a *xenograft model* due to their large brood size, transparency, ex utero development, easily amenable to gene knockout, lack of a mature immune system, and very low cost. Frogs share all of these advantages, but in addition, frogs have an extended larval period with only basic immune function and are larger in size, which could facilitate a broader range of experiments. Therefore, in this study, we have begun to develop a frog *xenograft* cancer model. We explored the creation of *xenografts* in two different life stages; juvenile and larval. The objective of this study is to examine conditions that allow a human cancer cells to grow in frogs. Our study preliminary results indicate that juvenile stages do not form noticeable tumors after 3 weeks. However, we note that at least one live larvae has a suspicious growth at the injection site, and another larvae that died had an abnormal growth. Future experiments are planned to examine the pathology of these growths and optimize the implantation technique using fluorescently labeled cells so that success rates and tumor size can be easily quantified. (Supported by NIH, VCU Bridges to the Baccalaureate R25GM102795). Author contact: ajdickinson@vcu.edu.

FINE-SCALE PATTERNS OF GENETIC STRUCTURE IN HOST PLANTS AND THEIR RHIZOBIA SYMBIONTS. Mahboubeh H. Nobarinezhad, Department of Biological Sciences, Mississippi state University & Lisa Wallace, Department of Biological Sciences, Old Dominion University. In this study, we tested fine scale genetic structure (FSGS) in the host plant *Chamaecrista fasciculata* and its rhizobia partner. Genetic structure of the plants was tested using 14 microsatellite markers and the identity of the rhizobia was determined using truA gene sequences. The results showed significant FSGS for both partners. We acknowledge Biology Faculty Fund of Mississippi State University for funding for this project and Old Dominion University for assistantship funding. Author contact: Mahboubeh H. Nobarinezhad, mh2329@msstate.edu.

NUCLEAR TRAFFICKING OF *ORIENTIA TSUTSUGAMUSHI* EFFECTOR ANK13 UTILIZES RADAR. N. B. Otto[1], H. E. Adcox[2], & J. A. Carlyon[2], [1]Thomas Nelson Community College and [2]Department of Microbiology & Immunology, Virginia Commonwealth University. *Orientia tsutsugamushi* is a mite-borne, pathogenic, obligate intercellular pathogen responsible for scrub typhus; a febrile and potentially fatal disease endemic to Asia and the western Pacific region. During infection, *O. tsutsugamushi* secretes multiple ankyrin-repeat containing proteins (Anks). When ectopically expressed in HeLa cells, one Ank in particular, Ank13, localizes to the host cell nucleus. It is known that some obligate intercellular pathogens secrete nucleomodulins; proteins that localize to host nuclei and modulate host genetic expression to create conditions favorable for the

pathogen. *O. tsutsugamushi* dysregulates gene transcription during infection, and it may be doing so through the use of Ank13 as a nucleomodulin. However, exactly how Ank13 localizes to the nucleus is unknown. When testing the most common pathway of nuclear import, recognition of a nuclear localization signal (NLS) by importin, it was shown that Ank13 enters the nucleus in an importin-independent manner. Ank13 appears to be utilizing the RanGDP-Ankyrin Repeats (RaDAR) pathway. In order to interact with RanGDP, a protein must have hydrophobic residues at the 13th position on two concurrent ankyrin repeats (ARs). We created mutants to test this hypothesis by observing their localization in transfected HeLa cells. These mutants had their 13th hydrophobic residues on AR4 and/or AR5 replaced with hydrophilic residues. SDS-PAGE gels and Western blots were performed on cytosolic and nuclear fractions of these cell lysates. To visualize the localization of Ank13 mutants in individual cells, we also performed immunofluorescence assays (IFAs). The results of these experiments suggest that Ank13 utilizes the RaDAR pathway for nuclear import. (Supported by NIH, VCU Bridges to the Baccalaureate R25GM102795). Author contact: jason.carlyon@vcuhealth.org.

INVESTIGATION INTO THE FUNCTION OF SACCHAROMYCES CEREVISIAE YLR149C AND SIR2 GENES IN THE PRESENCE OF HYDROGEN PEROXIDE AND NICOTINAMIDE MONONUCLEOTIDE. Leonid Smorodintsev-Schiller and Deborah Zies. University of Mary Washington. Genetic stability is crucial for well-being of an organism. Most of the de novo occurring mutations are detrimental, resulting is serious conditions such as type 1 diabetes and sickle cell anemia. Chemicals can affect genetic stability of an organism by altering either one of the intricate biological pathways or directly the DNA structure itself. Hydrogen Peroxide (H2O2) is well known chemical involved in formation of reactive oxygen species that are capable of damaging DNA. Another chemical, nicotinamide mononucleotide (NMN) can be used to generate NADH and NAD+, that can beneficially influence the stability of genetic material. The purpose of this study is to determine if the deletion of two Saccharomyces cerevisiae genes, YLR149C and SIR2, have an effect on genomic stability in the presence of hydrogen peroxide alone, or in the presence of both hydrogen peroxide and NMN. YLR149C was chosen because it is an ORF an gene with an unknown function, but has been shown to increase in expression during DNA damage. SIR2 was chosen because of its known role in NAD+ metabolism. Both genes, therefore may be involved in repair of genetic material. Mutation Rate Assay are being used to determine the frequency of novel mutations associated with the presence of the two chemicals in YLR149C deletion, SIR2 deletion, and wild type yeast strains. The results of these assays will be presented. This investigation will help to determine if SIR2 and YLR149C play in biological pathways active when organisms are exposed to the elevated level of H2O2 and nicotinamide mononucleotide. lschiller@mail.umw.edu

COMMON GENE VARIANTS IN G6PC GENE MAY CONTRIBUTE To FATTY LIVER DISEASE/HYPERLIPIDEMIA IN GENERAL POPULATION. Shan, Zaidi & Ancha, Baranova. George Mason University. Mutations in the *G6PC* gene, which encodes the catalytic subunit of Glucose-6-phosphatase, are found in patients with Glycogen storage disease 1a (von Gierke disease) and are associated with the

accumulation of glycogen and fat in the liver and kidneys. We hypothesized that heterozygous carriership of *G6PC* mutations may contribute to non-alcoholic fatty liver disease (NAFLD). To find support for this hypothesis, analysis of NAFLD-associated genetic networks was performed using Pathway Studio software; IGFB1 (Insulin Like Growth Factor Binding Protein 1) was identified as a connector between the NAFLD phenotype and *G6PC* expression and function. Moreover, PI3K/PKB pathway was highlighted as involved both in NAFLD and in von Gierke disease, with the activation of *G6PC* being a suppressor of NAFLD. Glucose carriers SLC2A2 and FBP1 were two other connectors between "weakened" *G6PC* and NAFLD. We also detected involvement of fatty acid synthase, TORC1 and the metabolic pathways of pyruvate and lactate. In hyperlipidemia, G6Pase is commonly overexpressed. The main outcome of the study is that new molecular targets for NAFLD are introduced through the Pathway Studio analysis for possible development of novel therapeutics. Author contact: szaidi14@masonlive.gmu.edu

Biomedical and General Engineering

ENHANCED EXCIPIENT GROWTH SURFACTANT REPLACEMENT THERAPY IN AN IN VIVO RAT LUNG INJURY MODEL. Franck J. Kamga Gninzeko[1], Michael S. Valentine[1], Sahil R. Chindal[1], Susan Boc[2], Sneha Dhapare[2], Michael Hindle[2], Dale Farkas[3], P. Worth Longest[3], & Rebecca L. Heise[1], [1]Dept. of Biomed. Engineering, [2]Dept. of Pharmacy, [3]Dept. of Mech. Engineering., Virginia Commonwealth Univ. IRDS, Infant respiratory distress syndrome is a form of respiratory distress syndrome that affects premature infant and the solutions that exist to remedy to the disease are breathing support and other therapies to keep the airway open and to prevent those airways from collapsing. A variety of drugs exist on the market to tame IRDS. These include, Alveofact®, Curosurf® and Survanta®. The common method of delivery for this drug is liquid deposition; however, it is not effective as the drug does not reach the small airways. We have developed an enhanced excipient growth (EEG) powder of Survanta that we delivered via an aerosolizer to Sprague Dawley rats. The rats were anesthetized, and surfactant depleted using 2 saline lavages. Then, the EEG powder was administered followed by a 10-minute mechanical ventilation (MV) at 8ml/kg. Ventilation mechanics were taken before depletion, after depletion, after the MV, bronchoalveolar lavage was performed and the cells were cytospun onto a microscope slide. We hypothesized that rats that receive EEG Survanta powder will have improved lung mechanics compared to the ones that received liquid Survanta. The results showed a significant improvement in compliance and elastance of EEG powder group compared to the liquid survanta. Finally, there was no significant difference in neutrophil count of the lavage obtained from the EEG powder group compared to the liquid survanta. Author contact: Franck Kamga Gninzeko kamgagninzefj@vcu.edu

VOLUNTARY DRIVE AMPLIFIES EFFECTS OF PAIRED-PULSE TMS AND ARM POSTURE ON BICEPS CORTICOMOTOR EXCITABILITY. Thibault Roumengous, Paul A. Howell & Carrie L. Peterson, Dept. of Biomedical Engineering, Virginia Commonwealth Univ. Non-invasive brain stimulation techniques are typically

applied at rest, but may be more effective or representative of neural changes when applied during a range of voluntary effort. We investigated the effect of voluntary drive on intracortical facilitation (ICF), short-interval intracortical inhibition (SICI) and static arm posture (AP) in the non-impaired biceps. Ten healthy participants (age 19 to 27; 7 males, 3 females) were seated in a chair with electromyographic (EMG) sensors placed on their dominant arm supinated in a cast attached to a force transducer. Baseline TMS trials consisted of single-pulse stimuli (120% resting motor threshold) delivered to the biceps cortical hotspot via a 110mm double cone coil (Magstim) during 0, 50, 75 or 100% MVC at 90° elbow flexion (AP90). Condition modifications involved modulating the elbow angle to 120° (AP120) and 45° (AP45), and addition of a conditioning TMS pulse of 90% RMT at an interstimulus interval of 1.5 ms for SICI (PP1.5) and 30 ms for ICF (PP30). A two-way ANOVA was performed to compare baseline (i.e., AP90 condition) measures of MEPs to all other conditions across voluntary effort levels. We found that high voluntary effort (≥ 50% MVC) increased ICF, SICI, and static elbow angle mediated changes in biceps corticomotor excitability. Thus, changes in corticomotor excitability may be more detectable at high voluntary effort. (Supported by VCU's CTSA -UL1TR000058- and the CCTR Endowment Fund). Author contact: Thibault Roumengous, roumengoust@vcu.edu

THE EFFECT OF INTERMITTENT THETA BURST STIMULATION ON CORTICOMOTOR EXCITABILITY OF THE BICEPS AND TRANSFERRED MUSCLES. Blaize C. Majdic, N Mittal & CL Peterson, Dept. of Biomedical Engineering, VCU. Motor re-education of the muscles is critical for attaining optimal outcomes in individuals with spinal cord injury (SCI) who have had an upper limb reconstruction (ULR) surgery. Neuromodulation of the primary motor cortex (M1) in pair with physical therapy may be a promising method for improving motor re-education after a ULR surgery. Increases in the excitability of the corticospinal motor pathway projecting to upper limb muscles have shown to be associated with motor learning and skill acquisition. The purpose of this study was to determine the effect of intermittent theta burst stimulation (iTBS) on the corticomotor excitability of the biceps and transferred muscles, as measured by motor evoked potential (MEP) amplitudes, in non-impaired (NI) individuals, individuals with tetraplegia, and individuals who have had an ULR surgery. It was found that change in MEP amplitude after iTBS was not different between sham and active coils in the NI group, while MEP amplitude was increased after active iTBS to a greater degree than sham in the SCI and ULR groups. This suggests that iTBS may be a promising method for improving motor outcomes for those with spinal cord injury and ULR. (Supported by the NIH National Center of Neuromodulation for Rehabilitation awarded to the Medical University of South Carolina). Author contact: Blaize Majdic, majdicbc@vcu.edu

GUIDED DEVELOPMENT OF NATIVE-LIKE LIGAMENT TO BONE JUNCTIONS. M. Ethan Brown & JL Puetzer, Dept. of Biomedical Engineering, VCU. Fibrocartilaginous osteoligamentous junctions are structurally complex tissues < 1 mm wide which connect elastic ligaments to stiff bone. They are composed of 4 zones with gradual transitions in collagen organization and biochemical composition to allow for functional mechanical load distribution between tissues. Engineered replacements have

failed to drive the formation of these unique zones necessary for long-term mechanical function. Previously we developed a culture system which guides ligament fibroblasts to develop aligned native sized and hierarchically organized 30 µm collagen fibers using high density collagen gels and mechanical boundary conditions. These constructs hold great promise as ligament replacements; however, development of an organized junction would aid their function *in vivo*. Compressive boundary conditions and the addition of beta tricalcium phosphate (βTCP) were used in conjunction with our previously developed system to drive the organization and development of zonal ligament-to-bone junctions. Statistical analysis was performed by 2-way ANOVA with SNK post-hoc analysis ($p<0.05$ significant). Glycosaminoglycan (GAG)/DNA remained constant for mid and transition zones but trended toward significantly increasing for βTCP clamped sections by 6 weeks, matching native junction development where GAG is elevated in neonatal interfacial regions and decreases with age ($p<0.056$). By 6 weeks, confocal imaging displayed βTCP samples resemble immature bovine junctions with zones of highly aligned parallel fibers in middle, perpendicularly aligned transition, and βTCP incorporated random, porous collagen network under boundary. Author contact: brownme9@vcu.edu

AGE-SPECIFIC ALTERATIONS IN LUNG MECHANICS AND MACROPHAGE POLARIZATION INDUCED BY HIGH PRESSURE-CONTROLLED MECHANICAL VENTILATION. Michael S Valentine[1], Franck Kamga Gninzeko[1], Sahil Chindal[1], Cynthia Weigel[2], Sarah Spiegel[2], Angela Reynolds[3], & Rebecca Heise[1]. [1]Biomedical Engineering, [2]Biochemistry and Molecular Biology, [3]Mathematics and Applied Mathematics, Virginia Commonwealth University. The largest population of patients requiring MV is the elderly, and age is a known predictor for the severity of VILI. Lung macrophages, which can be polarized into pro-inflammatory (M1) or anti-inflammatory (M2) phenotypes, greatly contribute to barrier integrity and local inflammation as mediators of injury and inflammatory signaling. Young (2-3mo) and old (20-25mo) mice were subjected to pressure-controlled MV (PIP: 35-45 cmH20, RR: 90 breaths/min, PEEP:0 cmH20) for 2 hours using a Scireq FlexiVent. This study suggests that aging results in significant alterations in lung structure/function and macrophage polarization, which are further impaired or exacerbated by PCMV. Furthermore, we provide evidence that these age-dependent negative outcomes correlate with decreased S1P signaling. Age-related differences in macrophage polarization mechanisms, such as those regulated by S1P, could be viable therapeutic targets for patients requiring MV by preventing or modulating the exaggerated inflammatory response, subsequent tissue injury, and impaired repair that often leads to sepsis and mortality. (Supported by: National Institute of Health 1R01AG041823-01A1, VCU Massey Cancer Center Lipidomics Shared Resource: NIH-NCI Cancer Center Support Grant P30 CA016059). Author contact: Michael Valentine, msvalentine@vcu.edu

COMPUTATIONAL ANALYSIS OF LISFRANC REPAIRS. M. Tyler Perez & Jennifer S. Wayne, Dept. of Biomedical Eng., Virginia Commonwealth University. While Lisfranc injuries in the midfoot are less common than other ankle and midfoot injuries, the outcomes of surgical repairs of these injuries remain poor. Existing literature has compared the different surgical procedures but has not concluded with a

recommended procedure. This study uses a computational biomechanical model to evaluate the ability of different surgical repairs to return the stability of the Lisfranc joint after an injury. Using SolidWorks™, a healthy human foot model was created whereby biomechanical function was dictated by accurate 3D articular anatomy, ligament restraints, and muscle loading. This model was validated on the experimental results for a cadaver study of a healthy and injured Lisfranc joint. Four surgical procedures that are used to repair Lisfranc joints were modeled. These were three open reduction and internal fixation (ORIF) procedures (endobuttons, screws, and dorsal plate hardware used) and arthrodesis with screws. A combination of rigid body modeling and finite element analysis was used to determine the mechanical stability in the joint (ie ability of the procedure to prevent separation in the joint) when the foot is loaded in a plantar flexed position. The von Mises stresses experienced by the different hardware were evaluated to determine where there was a risk of implant failure. Lastly, the contact forces with the ground and for joints adjacent to the Lisfranc joint were collected to compare the kinetics after surgery. Results showed ORIF with screws and arthrodesis had joint mechanics similar to a healthy foot. However, these fixation techniques with rigid hardware such as screws and plates showed areas of high stress that are at risk of fatigue failure. Author contact: Tyler Perez, perezmt@vcu.edu

DEVELOPMENT OF A DEVICE FOR THE QUANTIFICATION OF ARM RIGIDITY IN PATIENTS WITH PARKINSON'S DISEASE. Gina O. Miller & Paul A. Wetzel, Dept. of Biomed. Engineering, VCU. Parkinson's Disease (PD) is comprised of many symptoms which progress at different rates based on the patient, one of the most common being joint rigidity. This symptom, caused by the inability of the muscles to relax and extend properly, due to reduced dopamine levels, often begins in one arm and spreads through the leg on the same side of the body, then through the torso and the remainder of the body over time. The current standard for determining joint rigidity in a clinical setting is a subjective test completed by the clinician based on the feel of the relaxed wrist and elbow joints as they are flexed and extended. In some cases, an ordinal rating, determined through the use of the MDS-UPDRS, is used to scale the severity of the patient's rigidity, but there is no objectivity in these measurements either. We present a torque-based device to objectively quantify rigidity in a PD patient's arm. The device employs a servo motor-shaft assembly, connected to a rigid forearm sling and controlled by a computer to flex and extend the elbow joint in two possible orientations, pitch and yaw. A torque transducer and potentiometer will measure the torque necessary to rotate the shaft and the position of the shaft with respect to time, which can then be used to objectively determine joint rigidity. Angle of rotation, acceleration, and velocity of the shaft will be constantly monitored internally to ensure safety. By quantifying joint rigidity, clinicians will be able to more accurately track the progression of this symptom and the disease as a whole and administer appropriate medical care specific to an individual patient's PD progression. Author contact: Gina O. Miller, millergo@vcu.edu

SEGREGATED ANATOMICAL AND FUNCTIONAL SUB-CIRCUITS OF THE BASAL GANGLIA-THALAMOCORTICAL NETWORK DIFFERENTIALLY CONTRIBUTE TO DISTINCT MOTOR PATHOLOGIES INCLUDING DYSTONIA AND PARKINSON'S DISEASE. George R. Weistroffer[1,4], D

Kumbhare[2,4], PA Wetzel[1], & MS Baron[3,5], [1]BME, [2]Neurosurgery, [3]Neurology, VCU, [4]McGuire Research Institute, [5]SE PADRECC, VAMC, Richmond. The basal ganglia-thalamocortical (BGTC) motor network is organized into segregated re-entrant subcircuits originating from distinct premotor and primary motor territories. We previously reported that a precise neurotoxic ibotenate lesion in the ventral globus pallidus (GP) induces dystonia, while a discrete dorsal lesion induces parkinsonism. To delineate these individual subcircuits, we injected multi-synaptic anterograde neuronal viral tracers into these two GP hotspots and reconstructed the fluorescent labeling to the level of the motor cortex (MC). Florescent tagged vesicular stomatitis virus (rVSV) was locally administered into the above hotspot in GP (n=18 rats). After 2-4 days, the rats were perfused, and the brains were processed. Dense, circumscribed anterograde labeling of neurons was observed in the thalamus and MC. Initial higher-dose VSV injections maintained for 4 days (n= 5) produced identical dystonic symptoms as observed with neurotoxic lesions, validating the accuracy of the injection targets. Histological observations revealed the GP dystonia hotspot projecting to primary MC (L2.2, A2.1, D2.5) and the parkinsonian hotspot to secondary MC (L1.5, A2.4, D2). This study provides compelling evidence that dystonia and parkinsonism originate along separate motor BGTC subcircuits. This study is funded by VA BLR&D Merit Review award (M. Baron, PI). Contact author: George Weistroffer, weistroffegr@vcu.edu

Botany

STUDYING INTRASPECIFIC DIVERSITY CAN REVEAL NOVEL ASPECTS OF PLANT ECOLOGICAL INTERACTIONS AND EVOLUTIONARY DIVERGENCE. Lisa E. Wallace, Dept. of Biological Sciences, Old Dominion University. The study of intraspecific variation has long been considered important to the field of evolutionary biology because natural selection acts upon this variation to generate novel forms. More recently, intraspecific variation is recognized to influence ecological properties of ecosystems as well, often having equal or greater effects compared to interspecies diversity. Studies at the intraspecific level are necessary to link patterns with the processes that generate and shape the biodiversity that we see in Earth's present and past. In this presentation I provide examples of how intraspecific variation has contributed to eco-evolutionary diversification in two systems: endemic plants of the California Channel Islands and a widely distributed orchid species with a remarkable amount of floral diversity. These studies demonstrate that the degree of intraspecific variation varies immensely across space and species and that patterns of genotypic and phenotypic variation are often discordant. Intraspecific data sets have direct application in how we characterize and manage biodiversity, and species should be studied for both genotypic and phenotypic variation. Given the selection pressures experienced by organisms around the world due to climate change, studies of intraspecific variation are a critical piece in predicting how species and communities will respond to these changes. Author contact: Lisa E. Wallace, lewallac@odu.edu.

THE FLORA OF VIRGINIA PROJECT: A 2018-2019 PROGRESS UPDATE. Marion B. Lobstein, Professor Emeritus, Northern Virginia Community College. The

Foundation of the Flora of Virginia Project (FFVP) released the mobile version of *Flora of Virginia* App for Android and iOS systems in September 2017. This App contains an easy-to-use graphic key for use by the general public as well as inclusion of the dichotomous keys and descriptions at family, genus, and species level. The background chapters from the *Flora of Virginia*, a glossary, botanical illustrations, photographs, and county range maps from the Digital Atlas of the Virginia Flora are also features included in the App. Additional information on conservation ranks for rare or threatened species and scores for level of invasiveness for invasive species are also provided in the App. Additional photographs for the current species included in this mobile App have been added over this last year. Work is now underway on updating the *Flora of Virginia* App in an initiative called "Keeping the Science Current". This is part of Flora II to update the *Flora of Virginia* information since the 2012 publishing date. This effort will add approximately 150 new species to the App as well as current taxonomic changes. The descriptions at the species, genus, and family levels will need to be reflected in updated the dichotomous and graphic keys. Gary Fleming, recently retired chief ecologist for the Natural Heritage Program, has agreed to serve as the fourth author of the *Flora of Virginia* and he will be updating and expanding the ecological information of the species included in the App. Virginia Academy of Science support has been essential to the Flora of Virginia Project in the past and in the future. Author contact: Marion B. Lobstein, mblobstein@earthlink.net.

NOTES FROM NATURE - PLANTS OF VIRGINIA: AN UPDATE ON THE ONGOING DIGITIZATION OF VIRGINIA'S HERBARIA. Andrea Weeks, Dept. of Biology, George Mason Univ., Fairfax, VA 22030. In 2014, 11 Virginian herbaria (GMUF, FARM, VPI, LYN, VMIL, URV, LFCC, JMUH, VCU, BDWR, AVCH) began creating publicly-accessible online databases of their specimens, including high-resolution digital images (www.sernecportal.org). To date, 220,938 records have been digitized from the original eleven herbaria. Five herbaria have concluded NSF-sponsored digitization activities, four are in process, and the two remaining herbaria are slated to begin in 2019. Since 2014, Virginian herbaria have been added (PGC, LGBG) and lost (WYCO) from Index Herbariorum. In 2018, three additional Virginia herbaria (WILLI, ODU, MWCF) joined the SERNEC TCN initiative as an NSF PEN award, which will increase the number of digitized specimens from Virginia's Coastal Plain. LFCC will be permanently transferred to GMUF in 2019 and will be digitized, with grant support from the Virginia Native Plant Society. Lastly, research advances about the Virginia flora garnered from the digitized records from the are beginning to appear in the literature. Notably, the next edition of Flora of Virginia is referencing species records liberated by this effort and the known flora will expand as a consequence (Supported by Virginia Native Plant Society and National Science Foundation, EF-1410086 "The Key to the Cabinets: Building and sustaining a research database for a global biodiversity hotspot."). Author contact: Andrea Weeks, aweeks3@gmu.edu.

THE UNIVERSITY OF RICHMOND HERBARIUM FUNGI COLLECTION. W. John Hayden, Dept. of Biol., Univ. of Richmond, Richmond, VA 23173. The University of Richmond Herbarium (URV) includes 2750 specimens of lichenized and non-lichenized fungi most of which were assembled by R. F. Smart, his students, and his

colleagues in the 1930s and 1940s. Prominent collectors among the non-lichenized fungi include A. B. Seymour and F. S. Earle (177 Economic Fungi exsiccatae), F. A. Wolf (specimens from North Carolina), D. H. Linder (mostly Virginia collections); and J. L. Lowe (*Poria* from eastern North America). Included among the URV "fungi" are specimens of Oomycetes and Plasmodiophoromycetes, now considered to be non-fungal protists. E. S. Luttrell collected all groups of organisms while a student, but his most noteworthy contribution to URV consists of 1200 specimens of Virginia Cladoniaceae (lichenized fungi), assembled a few years after his graduation, while working for the Virginia Soil Conservation Service. Two other former students K. L. Poff and M. Ferrell collected ca 25% of the lichenized fungi at URV. Non-lichenized fungal specimens have been upgraded recently and are now enclosed in packets of acid-free paper affixed to standard herbarium sheets. Lichenized fungi are stored in packets held vertically in new acid-free trays. Label data for non-lichenized fungi at URV can be located on the Consortium of North American Lichen Herbaria web site. Author contact: W. John Hayden, jhayden@richmond.edu.

THE YEAR OF THE TREES: JMU CELEBRATES 30 YEARS OF OUTDOOR ENGAGEMENT IN A WOODLAND SANCTUARY. Conley K. McMullen, Dept. of Biology, James Madison Univ. & Jan Sievers Mahon, E.J. Carrier Arboretum, James Madison Univ. The year 2019 marks the 30th anniversary of an arboretum on the campus of James Madison University. The initial idea of converting part of the college woods into an arboretum began in the 1960s when Norlyn Bodkin arrived on campus. Over the years, this idea gained momentum, and in 1977 President Ronald Carrier approved the plans for an arboretum, and 26 acres were set aside for the project. Work began, slowly but surely, and in 1989 the arboretum opened to the public. In 1993, the arboretum expanded to 125 acres, with much of the added property comprising a forest of hardwoods that in 1998 was named The Norlyn L. Bodkin Oak-Hickory Forest. Also in 1998, the arboretum was officially named the Edith J. Carrier Arboretum in honor of JMU's 4th first lady. Other major projects over the years included creating a pond, erecting a pavilion for outdoor classes, and building an education center. The Edith J. Carrier Arboretum has developed into a woodland sanctuary on the JMU campus, and is a public urban garden and forested greenspace that preserves native plant species, provides opportunities for research, and promotes knowledge of the botanical and natural world for people of all ages. It is, a living laboratory that supports communal growth and involvement by presenting a place where flora and fauna can be appreciated, studied, and conserved; and its vision for the future continues to be to inspire outdoor engagement in a woodland sanctuary. Author contact: Conley K. McMullen, mcmullck@jmu.edu.

EVALUATING ATLANTIC WHITE CEDAR (*CHAMAECYPARIS THYOIDES*) TREE RINGS BETWEEN NON-TIDAL AND STORM-DRIVEN TIDAL WETLANDS. Jane F. Oswalt, J. Mitchell Doyle, & Robert B. Atkinson, Christopher Newport University. Atlantic White Cedar (*Chamaecyparis thyoides*, AWC) grows in a narrow range along the East Coast of the United States from Maine to Mississippi. Soils are acidic (~ 5.5 pH) and almost continuously saturated with freshwater. Less than 2% of stands remain, most harmed by ditching, fire, and logging. Now some of the most pristine stands are threatened by sea level rise as the current population lies within 70 m (200

feet) of sea level. This study contrasts AWC tree ring growth patterns with regard to water levels, precipitation, temperature, and drought intensity between the Great Dismal Swamp National Wildlife Refuge in Southeastern Virginia (3-7.5 m above sea level, GDS) and Alligator River National Wildlife Refuge in Northeastern North Carolina (<1 m above sea level, AR). GDS is an inland freshwater, drained peatland and AR is a coastal freshwater, storm-driven tidal wetland. Basal area increments (BAI) show GDS to have larger growth compared to AR but the biomass equal. The tree ring growth patterns of this species can help characterize the historic hydrologic regime in order to restore ditched sites; BAI trends signify AR as a restoration model for GDS. The next goal of this research seeks to isolate and understand the effects of saltwater intrusion from sea level rise in coastal stands. Author contact: Jane Oswalt, janeoswalt19@gmail.com.

AN ECOLOGICAL COMMUNITY SURVEY OF GAYLORD MARSH, A CALCAREOUS FEN IN CLARKE COUNTY, VIRGINIA. Daisy M. Blakely[1], Woodward S. Bousquet[1], Gary P. Fleming[2], Paul D. Poston[1], Hayden Bauserman[1], James Falletta[1], Emilio Rengifo[1], Collin Smeltzer[1], Jennifer Crider[1], Environmental Studies Program, Shenandoah University[1] and Virginia Natural Heritage Program[2]. Gaylord Marsh is located on private property in Clarke County, Virginia. Ecological communities had initially been surveyed in a single plot at the site in 1993. To more fully characterize the site, researchers in 2018 examined two more plots using the relevé method. A supplementary reconnaissance located noteworthy plant species outside the survey plots. A total of 63 vascular plant taxa, 33 of which occurred in the relevé plots, were documented. Seven county records, and 6 state-rare plant species were recorded. The county records and state-rare plants were all native to Virginia. Of the plant species found in the relevé plots, by dominance 98.9% were native and only 1.1% were introduced. By species richness, 97.0% were native, and only 3.0% were introduced. Of even greater surprise is that the dominant species *Carex utriculata* (beaked sedge) occurs in Virginia only at Gaylord Marsh. This research provides a baseline for future surveys at the site and the documentation of any changes in the vegetation that may occur. Author contact: Daisy M. Blakely, dblakely17@su.edu.

TARGET ENRICHMENT AND HIGH THROUGHPUT SEQUENCING APPROACHES TO RESOLVE THE MOLECULAR PHYLOGENY OF *PLATANTHERA* SECTION *LIMNORCHIS* (ORCHIDACEAE). Eranga H. Wettewa[1,2] & Lisa E. Wallace[2], Department of Biological Sciences, [1]Mississippi State & [2]Old Dominion University. *Platanthera* (Orchidaceae) is one of the largest genera of temperate orchids, with more than 200 species occurring in north temperate areas. Previous phylogenetic analyses in this genus have identified major radiations of species and tested sectional boundaries with respect to closely related genera, but we still lack a clear understanding of relationships among species within these major clades. *Platanthera* section *Limnorchis* has been identified as monophyletic in these previous analyses, and this group has long been recognized to be morphologically distinct from other *Platanthera* in North America. However, the recognition of several new species recently and morphological similarity of U.S. species with congenerics in Mexico and Asia have hindered a thorough understanding of species diversity and phylogenetic relationships in *Limnorchis*. In this project, we utilized one of the "reduced-

representation" methods, targeted-enrichment of low-copy nuclear genes to developed novel markers to use in estimating the phylogeny of section *Limnorchis*. We sequenced 24 samples collected from a wide geographic distribution, representing 22 *Platanthera* species, outgroup taxa and intermediates. Preliminary phylogenetic results of sequence variation in these markers are presented to test two hypotheses: 1) Section *Limnorchis* is monophyletic relative to other *Platanthera* species, 2) Species diagnosed by morphological characters are genetically divergent and represent distinct evolutionary lineages. Author contact: Eranga Wettewa, ehw89@msstate.edu.

ENCAPSULATION OF AFRICAN VIOLET (*SAINTPAULIA RUPICOLA* B.L. BURTT) SHOOT PRIMORDIA FOR MASS PROPAGATION. T. Warner Lowry & Michael H. Renfroe, Dept. of Biol., James Madison Univ. The *in vitro* propagation of plants is a promising method for the production of plants in species that are endangered, commercially valuable, and/or otherwise difficult to propagate through traditional horticultural methods. Leaf explants from critically endangered *Saintpaulia rupicola* were cultured on chemically defined media supplemented with various concentrations of thidiazuron (TDZ). These concentrations were effective in the production of shoot primordia that could then be encapsulated in a sodium alginate matrix to create synthetic seeds (synseeds). Synseed technology has potential in planting *in vitro* generated plant material in greenhouses to assist in the mass production of usable plants. Experiments were performed to determine if 2% or 3% sodium alginate was better for the emergence of the isolated shoot primordia. The 2% treatment had significantly more plants emerge and was used for the production of synseeds in later experiments. Various concentration of plant preservative mixture™ (PPM) were used to make synseeds to test the phytotoxicity of PPM. There were no significant differences seen between the concentrations. Finally, experiments were performed with 0.0 ml/L and 5.0 ml/L PPM in the synseeds on sterile vermiculite, non-sterile vermiculite, and non-sterile soil. Synseeds planted on non-sterile soil had significantly less plant growth than the other media treatments. All synseed experiments had some shoots emerge that then rooted and grew into full, new plants. The methods used are potentially useful in the mass production of new *S. rupicola* plants for the purposes of conservation both *ex situ* and *in situ*. Author Contact: T. Warner Lowry, lowrytw@dukes.jmu.edu.

Posters

THE STRUCTURES AND FUNCTIONS OF WOODY DEBRIS IN HEADWATER STREAMS OF THE NORTHERN SHENANDOAH VALLEY, VIRGINIA. Paul D. Poston, J.A. Kincaid, A.M. Rubano,Environmental Studies Program, Shenandoah University. Woody debris (WD) in headwater streams has been recognized to have direct impacts on channel morphology and sedimentation. The arrangements and characteristics of in-stream wood alters the velocity and direction of stream flow, which can facilitate increased bank erosion and sediment transport within the channel. This research documented the position and function of woody debris in headwater watersheds containing low to moderate human activity to determine if such activity influenced WD recruitment into streams and established sample sites to facilitate future research. Research sites were selected based on land use, located by GPS and surveyed. WD was

then measured and cataloged by station, position, function, and decay class. Sediment depth, stream bed composition, bankfull width, bankfull depth, and wetted width measurements were also cataloged and recorded before and after each wood structure. Results indicated that the volume of WD was unaffected by the change in human activities. Lower sediment measurements were recorded in areas having higher human activity which can be attributed to the increased runoff and water volumes released as a result of deforestation. Author contact: Paul D. Poston, Pposton17@su.edu.

Chemistry

EFFECT OF DIMERIZATION AND HALOGEN BONDING ON SUBSTRATE BINDING TO THE THYROID HORMONE DEACTIVATING DEIODINASE 3 PROTEIN. Eric S. Marsan & Craig A. Bayse, Department of Chemistry and Biochemistry, Old Dominion University. Iodothyronine deiodinases (Dio) are proteins which activate and deactivate thyroid hormones (THs) by regioselective removal of an iodine. Disruption of thyroid hormone homeostasis leads to detrimental side effects including hypothyroidism, cardiovascular disease, and structural abnormalities. Deiodination is induced by a selenium atom in the conserved selenocysteine (Sec) residue located in the active site of these proteins. Halogen bonding (XB) has been proposed as a possible means of deiodination of thyroid hormones. XB interactions occur between a nucleophile (usually a Lewis base) and a halogen, which serves as the lone-pair acceptor. The widely-accepted σ-hole model for XB emphasizes electrostatic interactions between the donor and acceptor. However, many computational docking studies fail to account for the σ-hole, often leading to inaccurate results. In addition, a crystal structure for the dimer of Dio3 has yet to be elucidated, which is the active form of this protein. In the present study, we perform Molecular Dynamics (MD) simulations on T_4-bound Dio3 by using the "dummy atom" method to account for the σ-holes on the ligand. In addition, we use the SymDock program to construct a dimer of Dio3 and optimize its structure using a symmetry-restraining method. RMS and H-bond analyses herein were used to characterize and identify important interactions and key residues within the protein. Author contact: emarsan@odu.edu.

PHOTO-RESPONSIVE METALLO-GELS. K. Ghebreyessus & A. M. Sallee, Dept. of Chemistry and Biochemistry, Hampton University. Metal-organic compounds that interact with external stimuli provide versatile materials for medicinal, biological, chemical, and electronic applications. A novel class of highly promising photo-switchable arylazopryazole (AAP) based molecular switches have been recently reported. The rate of photo-isomerization of these new systems can be easily modulated by the substitution pattern on the pyrazole ring. We present here a new type of photoresponsive low molecular weight metallo-gelators based on phenylalanine and 3,4,5-tridecoxybenzamide conjugated with AAP ligands that are able to respond to light and metal-complexation. The simple mixing of the gelators with different copper(II) and zinc(II) salts resulted in rapid formation of metallo-gels. We also screened different types of metal salts in search for an ideal gel forming condition. The results revealed that the gelation process is independent of the type of metal salts used. The photo-responsive

behavior of both the gelators and the matallo-gel was studied by UV-vis Spectroscopy. Upon Irradiation with UV light (l = 363 nm) the AAP molecular switches undergoes efficient reversible *trans*-to-*cis* photo-isomerization. However, the light-induced gel-to-sol transition of the metallo-gel was not observed. These results may suggest that the photo-isomerization of the AAP unit is blocked while in the gel state. (Supported by NSF PREM grant; award#:1827820). Kesete.Ghebreyessus@hamptonu.edu.

UNDERSTANDING THE EFFECT OF INTRAMOLECULAR AND INTERMOLECULAR INTERACTIONS ON ENERGETIC MATERIAL SENSITIVITY. Ashley L. Shoaf & Craig A. Bayse, Department of Chemistry and Biochemistry, Old Dominion University. High energy density materials (HEDMs) with improved properties are under investigation to replace hazardous materials currently used in military and aeronautics applications. However, experimental data is limited because detonation is practically instantaneous; thus, information from density functional theory (DFT) could be used to predict energetic properties from bond activation measures. Trigger bonds, activated bonds that break to initiate explosive decomposition, are proposed based on DFT calculations and the Wiberg bond index (WBI), a measure of interatomic electron density. WBIs of HEDM trigger bonds were compared to those in reference molecules (i.e. contain same bond type and hybridization) to determine a relative scale for bond activation (%ΔWBIs). Trigger bonds are expected to be longer, have a lower electron density and be activated by repulsion and steric effects relative to the corresponding bond in reference molecules. Since detonation is a unique solid-state process, gas-phase calculations guide condensed-phase calculations to understand the favorability of certain initiation pathways. Thus, molecular dynamics simulations show how intermolecular interactions change over time with increasing pressure. Correlating %ΔWBIs to experimental data could provide insight into the effect of intramolecular interactions on sensitivity while molecular dynamics can show how intermolecular interactions influence sensitivity.

TRANSFORMATION OF SILVER NANOPARTICLES IN ANIONS. Peter N. Njoki, Department of Chemistry and Biochemistry, Hampton University. A laboratory experiment was developed to demonstrate the transformation of silver nanoparticles (Ag NPs) in water containing phosphate and sulfate anions. The experiment, conducted by high school students, involved hands-on training on synthesis of Ag NPs and characterization of the NPs via ultraviolet−visible (UV−Vis) spectroscopy. This was followed by UV−Vis examination of the change in absorbance and wavelength during the interaction of NPs with phosphate or sulfate anions. This study helped the students appreciate the transformation of NPs in aquatic environment containing anions. (Supported by: National Science Foundation HBCU-UP ACE Implementation. HRD-1238838). Author contact: peter.njoki@hamptonu.edu

ANALYSIS OF THE LIGHT INDUCED DEGRADATION OF NITROCELLULOSE LACQUER COATINGS USING VARIABLE TEMPERATURE REFLECTION ABSORPTION SPECTROSCOPY. Taylor W. Pryor & H. Francis Webster, Department of Chemistry, Radford University. In this paper nitrocellulose was coated on silver on the order of < 100 nm thick. This was then run in

FTIR while heating to get the normal degradation temperature of an undamaged film, and in TGA to view the mass as a function of temperature. Then new coated samples were exposed to different wavelengths of light 254 nm (UVA), 310 nm (UVB), and 365 nm (UVC). As thought the lower the wavelength the shorter length of time it took to destroy the nitro peaks as measured by FTIR. With the 254 nm light the destruction time of the nitro peak was ~0.5 hours, the 310 nm was ~12 hours, and the 365 nm was still present after 500 hours. Because of this the 365 nm was selected as the wavelength of interest and run out to 500 hours of exposure. These were done in a photo reactor with 365 nm bulbs at a constant humidity and constant temperature. These were then heated and the shift in degradation were plotted as area ratios. What was found as a function of time was that as the film became damaged that it began to decay at a lower temperature, and the total loss of the 1670 cm-1 peak occurred at a lower temperature. The undamaged polymer degraded in TGA at 180 °C vs 173°C using the RASTA technique while the 500-hour trial began to degrade at 139°C using the RASTA method. Author contact: tpryor5@radford.edu

SYNTHESIS AND ANTIMICROBIAL ACTIVITY OF SPIRO-OXINDOLES. Vincent de Paul Nzuwah Nziko[1], B. Bennette[1] & S. M. N. Efange[2], [1]Department of Chemistry and Biochemistry, Hampton University, Hampton, VA 23668, [2]Dept. of Chemistry, University of Buea, Cameroon. Spiro [indole-3,3'-pyrrolidin]-2(1H)-one analogs were synthesized via an intramolecular Mannich reaction. These compounds were investigated for their ability to inhibit in vitro the growth of D10 Plasmodium faciparum, K1 Plasmodium faciparum, Trypanosoma cruzi, trypanosoma.b. rhode- siense and Leishmania donovani. Compounds 73b was the most promising as inhibitors of both D10 and K1 P. falciparum. However, the compounds are not as efficient as chloroquine. Structure-activity relationships (SAR) and quantitative structure-activity relationships studies were carried out on this series. Our results allowed us to determine the minimal structural requirements for antiplasmodial activity in this series of compounds.

INVESTIGATION INTO THE EFFECT OF HETEROATOM CONTENT ON KEROGEN STRUCTURE USING ADVANCED 13C SOLID-STATE NMR SPECTROSCOPY. Wenying Chu1, Xiaoyan Cao2, Klaus Schmidt-Rohr2, Justin E. Birdwell3 & Jingdong Mao1, 1Dept. of Chemistry & Biochemistry, ODU, 2Dept. of Chemistry, BU, 3Central Energy Resources Science Center, USGS. Three shale samples containing kerogen with extreme hereroatom contents were selected to study the effect of heteroatom concentrations on kerogen structures. Advanced 13C solid-state nuclear magnetic resonance (NMR) techniques, including multiple cross-polarization/magic angle spinning (multiCP/MAS), dipolar dephasing (multiCP/DD), and 2D 1H–13C heteronuclear correlation (2D HETCOR) were applied to the samples. The high oxygen content in Estonian kukersite corresponded with abundant aromatic C-O structures and that nonprotonated aromatic carbons bonded to oxygen and alkyl chains led to more diverse aromatic signal distributions and structures in the kukersite organic matter than were observed in the other shales. The low-heteroatom kerogen in Australiam Glen Davis torbanite had the simplest structural pattern and the lowest aromaticity. The organic sulfur-rich Ghareb marinite from Jordan contained the highest aromaticity and most diverse alkyl structures among the three shales. Consistent with previous studies of shales

and kerogens, NMR provides deeper insights into structural characteristics in organic matter than kerogen typing based solely on elemental ratios (H/C, O/C) or programmed pyrolysis parameters. Author contact: wchu@odu.edu

DEVELOPING SMALL MOLECULE INHIBITORS FOR CALPAIN DEPENDENT DEGRADATION OF DESMOPLAKIN. Kendahl L. Ott[1], Taylor L. Albertelli[1], Nathan T. Wright[1], Heather Manring[2], Maegen A. Ackermann[2] & Stuart Campbell[3], [1]Department of Chemistry and Biochemistry, James Madison University, [2]Department of Physiology and Cell Biology, Ohio State University, [3]Department of Biomedical Engineering, Yale University. Desmoplakin (DSP) is a large (260 kD) protein found in the desmosome, a subcellular structure that links the cytoskeleton of one myocyte to that of its neighbor. In cardiomyocytes, desmoplakin's main function is to maintain cell-to-cell adhesion and synchronization during heart contractions. A mutation hot-spot, centered around the SH3 domain of DSP, is associated with arrhythmogenic cardiomyopathy, but the underlying mechanism(s) of this association isn't well studied. Through various fluorescence techniques, it can be shown that many of these disease-causing mutations display increased calpain sensitivity. Additionally, structural and computational studies on DSP variants show that this cleavage event is driven not through a gross structural change, but instead through the discrete exposure of a normally-occluded calpain cleavage site. Initial *in silico* and *in vitro* screens of small molecules suggest the feasibility of developing a pharmaceutical solution to prevent calpain-mediated DSP cleavage. (Supported by: NSF REU (CHE-1757874), NSF RUI MCB-1607024, Henry Dreyfus Teacher-Scholar Award & VAS Undergraduate research minigrant). Author Contact: Kendahl L. Ott, ottkl@dukes.jmu.edu

MOLECULAR MODELING AND DRUG MAPPING HEMOLIN PROTEIN WITH DRAGOMABIN ANALOG. Michelle K. Waddell, Dept. of Chem. & Biochem., Hampton University. Malaria is a mosquito-borne disease carried primarily by the *plasmodium falciparum* parasite. Over time the parasite has developed resistance to several antimalarial drugs. Dragomabin, a bioactive isolate of marine cyanobacteria, *Lyngbya majuscule*, has shown activity against Chloroquine-resistant parasites although the mechanism is not fully understood. The objective of this research was to improve the activity rate of Dragomabin through computational modeling of a protein that binds to Chloroquine in a similar manner. The selected protein, Hemolin, is an insect immunoglobulin superfamily member and a lipopolysaccharide-binding immune protein induced during bacterial infection. The CheMagic.com Virtual Molecular Model Kit was utilized to construct the Dragomabin molecule, and was later used to import the Hemolin protein from ProteinDataBank.com. Protein Data Bank Extract was then later used to create Cartesian coordinates to be imported into Auto Dock in order to bind Hemolin with Dragomabin. A series of Dragomabin analogs were modeled using both CheMagic.com Virtual Molecular Model Kit and ChemDraw 3D 16.0. Dragmobin analog 5 was found to have the most effective binding affinity to the Hemolin protein. (Supported by: U.S. Department of Education Ronald McNair Post-Baccalaureate Program at Hampton University). Author contact: Michelle K. Waddell, michelle.waddell@hamptonu.edu.

ENGAGING UNDERGRADUATES IN RESEARCH THROUGH DPAL (DISTRIBUTED PHARMACEUTICAL ANALYSIS LABORATORY): SCREENING FOR LOW QUALITY PHARMACEUTICALS USING ATOMIC ABSORPTION SPECTROSCOPY. Maria A. Puccio. Dept. of Natural Sci. and Math. Ferrum College. Method development, quality assurance, and calibration are concepts that can be difficult to convey to undergraduate students. Many undergraduate labs follow a "cook-book" recipe in which the method is already developed, quality assurance isn't required, and students struggle to understand what calibration is for. DPAL is a citizen scientist group which partners with pharmacists in low-income countries to obtain samples for potentially low quality or falsified medicines. These samples are then distributed to undergraduate institutions in the DPAL network for analysis. This offers a real-world problem for undergraduate students to tackle. Students at Ferrum College are currently developing a method for the analysis of magnesium from magnesium sulfate injection solutions (used in the treatment of preeclampsia). This work will present the results of the first phase of method development and the plans for incorporating DPAL into research and undergraduate courses next semester. Author contact: mpuccio@ferrum.edu.

THE REACTIVITY OF SELECTIVE ZINC FINGER PROTEINS WITH REDUCIBLE SULFUR AND SELENIUM COMPOUNDS – A QM/MM STUDY. Ana Dreab[1], Patricia B. Lutz[2] & Craig A. Bayse[1], [1]Dept. of Chemistry & Biochemistry, Old Dominion Univ. [2]Dept. of Science, Technology & Mathematics, Regent Univ. Zn-S centers are important to different biological processes such as DNA transcription and repair, biochemical recognition and protein regulation. Zinc finger (ZF) regions of transcription proteins, which are found as three classes (Cys_4, Cys_3His and Cys_2His_2), are an important subset of zinc-binding proteins. Reducible sulfur and selenium (r-S/Se) compounds eject Zn^{2+} from zinc-sulfur proteins. The Zn^{2+} ejection leads to the loss of the tertiary and quaternary structure of the protein and therefore the loss of its functions. The underlying mechanism is poorly understood and a fully characterization is required to design and use specific sulfur- and selenium-based inhibitors of the therapeutic potential. In the current work, the mechanism of Zn^{2+} release from Cys_4 – type ZFs by ebselen and dithiones are explored through a series of QM/MM studies that addresses both the energetics and the sterics of the interactions. Both the charge and the solvent accessibility of all ZF Cys S atoms are calculated to determine the most favorable site for the attack of the electrophilic r-S compound. The preliminary data is in agreement with our previous gas-phase calculations and the results are compared with the experimental data, when available. (Supported by: The Virginia Academy of Science). Author contact: cbayse@odu.edu

THEORETICAL STUDIES OF THE NON LINEAR OPTICAL PROPERTIES (NLO) OF A SERIES OF DITHIENOPYRROLE-BASED DONOR-PI-ACCEPTOR (D-P-A) DYES. Edmund Moses N. Ndip, Dept. of Chemistry and Biochemistry, Hampton University. The changes in the structure, linear and nonlinear optical (NLO) properties of several organic semiconductors as the donor / acceptor strengths and substituent groups on N of pyrrole moiety are changed have been investigated. These include geometrical parameters, dipole moments, HOMO-LUMO

energy gaps, absorption wavelengths, and total polarizabilities and hyperpolarizabilities. Semi-empirical calculations of the frequency-dependent linear polarizability, α, the second, β- and third, γ-order hyperpolarizabilities at the fundamental (1028 nm) and other wavelengths were achieved by applying the *ab initio* time-dependent coupled perturbed Hartree -Fock (TDCPHF) method at the Restricted Hartree- Fock (RHF) level using routines contained in MOPAC2016 program. Donor groups studied include $(C_6H_5)_2N$-, $(CH_3)_2N$-, and CH_3O-. Acceptor groups studied include –CHO (aldehyde), cyanoacrylic acid, $=C(CN)CO_2H$, cyanoacrylic amide, $=C(CN)CONH_2$ and rhodanine. The polarizability and hyperpolarizabilities exhibit discernible frequency dependence. Higher level calculations using first principles *ab initio* methods (DFT, TDDFT and others along with large basis sets including polarization functions are planned for the future to verify the observed trends. This work was supported in part by Hampton University – Brandeis University NSF DMR PREM grant. Author contact: edmund.ndip@hamptonu.edu

THERMAL DEHYDRATION OF METAL SALT HYDRATES. T.C. DeVore, Isatu Kanara & James Harness, Dept. of Chemistry and Biochemistry, James Madison Univ. The thermal hydration-dehydration cycles of metal salt hydrates are being investigated for use in devices that can be used to harvest water from the atmosphere. The dehydration pathways of $MgSO_4 \cdot 7\ H_2O$ has been investigated under several experimental conditions. The first water is lost by 300 K to form $MgSO_4 \cdot 6\ H_2O$. The next five waters of hydration are apparently lost in one step to form $MgSO_4 \cdot\ H_2O$ in uncapped cells in flowing nitrogen. However, as the rate of transport is slowed by putting a cap on the cell, intermediates of $MgSO_4 \cdot n\ H_2O$ with n = 3, 2, 1 are also observed. Model free and isothermal kinetics indicates that the dehydration also passes through these intermediates in uncapped cells. Isothermal kinetics data can be fit using the contracting volume mechanism. However, the apparent activation energy decreases slightly as the sample mass increases suggesting that even in uncapped cells, the dehydration is following a quasi-equilibrium mechanism. Author contact: devoretc@jmu.edu.

Posters

DETERMINING THE CHEMICAL THERMOSTABILITY OF THE DIMERCAPROL COMPLEXES WITH MERCURY AND LEAD IN TREATING HEAVY METAL POISONING. Briana Roberts, Stephanie Chigbu & Insu Frank Hahn, Dept. of Chemistry and Biochemistry, Hampton University. Exposure to metals such as lead (Pb) and mercury (Hg) have been found to cause heavy metal poisoning. Chemical chelation therapies with chelating agents, including Dimercaprol (BAL) and Succimer (DMSA), have been applied to treating the heavy metal poisoning by capturing toxic heavy metals in the cardiovascular and lymphatic systems. There has been lack of understanding of the thermochemistry of the metal complex compounds with chelating agents used in chelate therapy for heavy metal poisoning. Here, theoretical semi-empirical AM1 (Austin Model 1), PM3 (Parameterized Model number 3), and MNDO (Modified Neglect of Diatomic Overlap) calculations for the newly constructed 3-D models of controlled dimercaprol with Pb^{+2} and Hg^{2+} were conducted in gas and water phases to investigate the intrinsic thermochemical coordination bond properties, ie.,

stability and reactivity of biological-inorganic chelates for chelation therapy in heavy metal poisoning, via MOPAC (Molecular Orbital Package) simulations. The newly obtained comparative thermochemical data in this study may contribute toward new chelate therapies, drug development and its applications. (Supported by NSF HBCU-UP ACE NANOHU PROGRAM, Hampton Univ.). Author contact: insu.hahn@hamptonu.edu.

INVESTIGATING THE STABILIZING EFFECT THAT PENICILLAMINE HAS ON HEAVY METAL POISONING. Mercedes Matlock, Arielle Patterson, Briana Roberts & Insu F. Hahn, Dept. of Chemistry and Biochemistry, Hampton University. It has been reported that exposure to metals such as lead (Pb), mercury (Hg), chromium (Cr), arsenic (As), iron (Fe), etc. can cause heavy metal poisoning. Chemical chelating agents such as Penicillamine, Dimercaprol, Ethylenediaminetetraacetic acid and Succimer have been used for inorganic chelation therapy to treat the heavy metal poisoning by capturing toxic heavy metals in the cardiovascular and lymphatic systems. These chelated metal complexes are then excreted through the urine. However, no thorough thermochemical stability investigations on the chelated metal complexes for chelation therapy have been reported. In this study, semi-empirical AM1 (Austin Model 1), PM3 (Parameterized Model number 3), and MNDO (Modified Neglect of Diatomic Overlap) quantum chemical approximations for the newly constructed 3-D models of controlled penicillamine complexes with Pb^{+2} and Hg^{2+} were conducted in gas and water phases to examine the intrinsic thermochemical stability and reactivity of the biological-inorganic chelates being used in chelation therapy for heavy metal poisoning. The newly obtained comparative thermochemical data via MOPAC (Molecular Orbital Package) simulations may contribute toward new chelate therapies and drug development. (Supported by NSF HBCU-UP ACE NANOHU PROGRAM, Hampton Univ.). Author contact: insu.hahn@hamptonu.edu.

THE EFFECT OF TRIGGER BONDS IN ORGANIC CAGE MATERIALS USING WILBERG BOND INDEX ANALYSIS. Mohamamd Jaffar & Craig A. Bayse, Dept. of Chemistry and Biochemistry, Old Dominion University. Energetic materials (chemical explosives) have a high amount of stored chemical energy that can be released when their bonds break under stimulus (stress, heat, shock). We have examined the trigger bonds in a series of cage molecules. The Wiberg bond index and bond lengths are calculated in order to estimate the compounds' sensitivity and to develop a "green" explosives. Organic-cage compounds based on prismane and cubane have large strain energies, high heat of formation, and compact structure and may be comparable to known energetic materials, like TNT. A classic example of cage-like energetic materials is CL-20.

$$\%\Delta \mathrm{WBI}_{\mathrm{AB}} = \frac{\mathrm{WBI}_{\mathrm{AB}}(\mathrm{HEDM}) - \mathrm{WBI}_{\mathrm{AB}}(\mathrm{reference})}{\mathrm{WBI}_{\mathrm{AB}}(\mathrm{reference})} \times 100$$

Wiberg Bond Indices (WBIs), a measure of electron density between two atoms in a bond. The trigger bond was assigned for a molecule based on the negative value of %ΔWBI relative to the reference. Examples of references we used, nitromethane ($C(sp^3)$-NO_2), dimethylnitroamine ($N(sp^3)$-NO_2), and nitroester ($O(sp^3)$-NO_2). Author contact: cbayse@odu.edu

EFFECT OF HYDROGEN BONDING ON THE CONFORMATION DYNAMICS OF AN Ω-LOOP OF IODOTHYRONINE DEIODINASE. Alexis Tran-Thompson, Jenna R. Garcia, Eric S. Marsan & Craig A. Bayse, Department of Chemistry and Biochemistry, Old Dominion University. Iodothyronine deiodinases (Dios) are selenocysteine-dependent enzymes that activate and deactivate thyroid hormones through elimination of iodide. Mutations at key residues can prevent deiodination to disrupt developmental and metabolic processes. Multiple μs molecular dynamics simulations using AMBER have been performed on the wild-type of Dio3 and its Ser167Ala, Thr169Ala, and Glu200Thr mutants to understand the structural effects of mutation on a critical omega-loop that is believed to contribute to substrate binding and activation. Hydrogen-bonding interactions between loop residues and the active site define the conformation of the loop and presumably substrate selectivity and the activity of the protein. Hydrogen bonding interactions between loop residues and the side chains of the Ser167/Thr169 residues at the active site pin the loop to the bulk of the protein. Mutations of these residues significantly increase loop flexibility, which likely results in diminished substrate binding and loss of activity. (Grant-in-aid of Research, The National Institute of Health). Author contact: Alexis Tran-Thompson, ttran014@odu.edu.

EXAMINING THE TEMPORAL DYNAMICS OF CASPASE-8 ACTIVATION IN THE EXTRINSIC PROCESS OF APOPTOSIS. Catherine H. Zwemer & Randall D. Reif, Dept. of Chem., Univ. of Mary Washington. Apoptosis is a process of cell death that occurs within the body. Caspases are a family of enzymes which activate each other to degrade cellular proteins leading to the death of the cell. The steps of apoptosis are well known, however the timing of caspase activity within the cell is not. The purpose of this research is to understand the temporal dynamics of the caspase-8 activation in the extrinsic pathway of apoptosis. Cells are examined by fluorescence microscopy using an affinity microfluidic device and a fluorogenic caspase probe derived from Rhodamine 110. Fluorescence is monitored over a period of 6 hours, indicating the level of caspase activity within the cell. This procedure is conducted for caspase-8 using a $IETD_2R$ probe. Caspase-8 activity was shown to start 1.6 hours post-induction lasting 180 minutes. Understanding the timing of caspase activation could be helpful in designing apoptosis-targeted therapies. Author contact: czwemer@mail.umw.edu.

Data Science, Computing and Statistics

MACHINE LEARNING TECHNIQUES FOR MALWARE CLASSIFICATION. Yen-Hung (Frank) Hu[1], Abdinur Ali[2], Chung-Chu (George) Hsieh[1] & Aurelia Williams[1]. [1]Department of Computer Science and [2]Department of Mathematics, Norfolk State University. Today's malware is more sophisticated than its predecessors and has the ability to obfuscate and change its activities, which increases the difficulty of detecting and classifying its identity. For instance, it is difficult to detect and identify advanced persistent threats (APTs) if they can clean their attack traces and logs and leave nothing behind. Many approaches have been investigated in the past decade, yet there still lacks a

comprehensive solution to solving such an issue. Machine learning technology could be a promising approach for classifying malware with none or few known traffic patterns and activity logs, because it can learn new information about unknown malware and be trained to adapt to such knowledge. In this research, we study the performance of several machine learning algorithms for classifying malware. Ten machine leaning algorithms are used to classify a Microsoft Kaggle dataset consisting of nine pieces of malware identified by their API calls and N-grams signature patterns. The performance metrics used in this research are Time to Build Model (TBM), Correctly Classified Instances (CCI), Kappa Statistics (κ), Root Mean Squared Error (RMSE), True Positive Rate (TPR), F-Measure, Matthews Correlation Coefficient (MCC), and Receiver Operating Characteristic Area (ROCA). We study and analyze performance metrics of every selected machine learning algorithm against every selected malware. Our research results show that Random Forest machine learning algorithm is the best one for classifying the selected malware since it has the best overall performance. Author contact: yhu@nsu.edu.

EXPLORING DATA REMANENCE IN VOLATILE MEMORY. Travis Bresnahan & Robert Marmorstein, Dept. of Computer Science, Longwood University. Information stored in Dynamic RAM is typically supposed to be volatile in the sense that it disappears when power is removed from the system. Many security mechanisms, including authentication and authorization systems depend on this assumption. Previous work shows that under certain conditions data may be recoverable after a reboot for a substantial period of time. However, previous work has focused on systems running the Windows operating system. In this project, we examined data remanence on Linux workstations. We were unable to demonstrate remanence affects, suggesting that future work is warranted in this area. (Supported by a CURIO grant, Office of Sponsored Research, Longwood University). Author contact: marmorsteinrm@longwood.edu

A CASE STUDY OF WEARABLE TECHNOLOGY VULNERABILITIES – FITBITS. Yen-Hung (Frank) Hu, Felton Blow, Mary Ann Hoppa. Department of Computer Science, Norfolk State University. Wearable devices are being developed and brought to market so rapidly that security and risk management often appear to be overlooked. As the use of wearable devices continues to grow at an incredible rate, so do device vulnerabilities, and along with them security and privacy risks. In the wrong hands, the data that wearable devices collect can potentially cause more harm than data from smartphones and other devices. Wearable devices have created another attack vector, and, if not appropriately controlled or governed, can facilitate the compromise of data confidentiality, availability and integrity for users and organizations. Wearable devices are in high demand because of their ability to deliver useful functionality both conveniently and in real time. These devices also are embedded with sensors that enable the collection of vast amounts of information. Some of the key sensors are accelerometers, gyroscopes, Global Positioning System (GPS), acoustics and voice detection. Since these built-in sensors gather personally identifiable information (PII), users and organizations become subject to vulnerabilities and cyber-threats. This research explored cybersecurity vulnerabilities, threats, and risks related to wearable devices using the Fitbit smartwatch as a popular example. Analysis focused on the sensors that are

integrated into such devices. Understanding how these components work exposed ways they can be exploited, which in turn suggested ways to mitigate potential cyber-attacks on wearable devices. Author contact: yhu@nsu.edu

A NOVEL AUTONOMOUS VEHICLE ROUTE PLANNING SYSTEM. Susan Zehra, Syed R Rizvi, & Stephan Olariu, Dept. of Computer Science, Old Dominion University, Norfolk, VA 23529. We propose and simulate a novel autonomous vehicle route planning system called an Agent-assisted Smart Auction-based Parking (ASAP) system for Autonomous Vehicles (AVs). Urban parking is taken as a use case for illustration and validation. In order to improve parking space allocation, we incorporate an auction mechanism. ASAP leverages truthful bidding from the bidders while providing higher utilization to Parking Facility Providers (PFPs) due to the inherent ability of AVs to move without the presence of an actual human in them, thus increasing revenue. The main contribution of this paper is the introduction of a parking auction through sophisticated software agents that are capable of quickly and seamlessly performing tasks such as parking lookup, negotiation, pricing, and reservation. Simulation results show that the proposed scalable and interactive agents of ASAP enable efficient processing of a vast amount of data, providing cost savings for parkers looking for parking, and improving usability of public and private parking facilities. Author contact: szehra@odu.edu

VULNERABILITY ASSESSMENTS FOR SCADA DEVICES. Yen-Hung (Frank) Hu, Dawn Silverman & Mary Ann Hoppa. Department of Computer Science, Norfolk State University. Supervisory Control and Data Acquisition (SCADA) technology has evolved since its inception in the 1950's through four generations. Each generation has brought new capabilities and a more scalable network as the performance of SCADA devices has increased throughout the years. Each generation has brought new vulnerabilities, challenges, and opportunities for securing SCADA-enabled systems from malicious attacks. SCADA devices have increasingly become targets of malicious actors, alerting industries, governments and private citizens to the need for more effective security measures, particularly for critical infrastructure and industrial control systems (ICS). These systems throughout the United States and abroad are dependent on SCADA devices to automate and monitor processes. They deliver essential services, including electric power and purified water, to residential and commercial properties where a sustained interruption could create a crisis with dire consequences. To address concerns on this issue, a thorough survey and investigation was conducted on cyber-attacks targeting SCADA systems to propose solutions and recommendations for mitigating such attacks. This research first studied some historical perspectives on SCADA and associated risks, including examples of typical attacks. Some general recommendations were made for methodically securing SCADA networks. The long-term objective of this research is to better secure the future of SCADA and, by implication, the critical infrastructures that depend on this technology, through more focused cybersecurity vulnerability assessment and mitigation. Author contact: yhu@nsu.edu

INTERNET OF THINGS COMMUNICATIONS FOR SMART CITY: A HOLISTIC ARCHITECTURE. Susan Zehra, Syed R Rizvi, & Stephan Olariu, Dept.

of Computer Science, Old Dominion University, Norfolk, VA 23529. An architecture based on Internet of Things (IoT) communications for use in a smart city is proposed and simulated in this research. Urban parking is taken as a use case for illustration and validation. The system design is a lightweight, scalable, and adaptable system that automates the workflow of reserving the best parking spots. It employs a novel parking broker – a software agent that leverages valuable route planning information from other traffic information services, and promotes road-safety by minimizing the need for parkers to interact with their smartphones or onboard units, thus reducing distracted driving. In addition, the parking record collected by the system can provide local governments with statistics for building future parking lots. The proposed parking network and architecture, system workflow, strategy model, and simulation highlight the importance of desirable features such as satellite navigation, indoor navigation, event data recording, parking reference, traffic and weather information, and parking reservations. Author contact: szehra@odu.edu

Education

(Not Available)

Entomology

ROLE OF *IXODES SCAPULARIS* SPHINGOMYELINASE-LIKE PROTEIN (*IsSMase*) IN TICK-BORNE PATHOGEN TRANSMISSION. Pravesh Regmi, Supreet Khanal, Girish Neelakanta & Hameeda Sultana, Old Dominion University. *Ixodes scapularis* (hard tick) is one of the major vectors which is involved in arthropod borne disease transmission. Langat virus (LGTV) is a model pathogen to work in the research laboratory, which resembles both antigenically and phylogenetically with other medically important flaviviruses such as Tick-Borne Encephalitis virus (TBEV) and Powassan virus (POWV). Sphingomyelinase-like protein (*IsSMase*) is a molecule present in ticks that helps to catalyze hydrolysis of the sphingomyelin (cell membrane lipid) into phosphorylcholine and ceramide. Our study suggests that *IsSMase* expression is downregulated in presence of tick-borne LGTV-infected cells. Time and dose dependent post-infection was performed to detect the *IsSMase* expression. LGTV loads increased in tick cells, however, *IsSMase* expression was downregulated with the increase in time and dose dependent LGTV post-infection. Similar results were obtained with LGTV-infected unfed Nymphal ticks. Our data suggests that *IsSMase* is downregulated in tick cells and in ticks with the increase in LGTV viral loads. This work was supported by start-up funds from Old Dominion University to H.S. Author contact: Pravesh Regmi and Hameeda Sultana, pregmoo2@odu.edu and hsultana@odu.edu.

DEVELOPING A PEST MANAGEMENT PLAN FOR EDAMAME PRODUCTION IN VIRGINIA. Kemper L. Sutton, Thomas P. Kuhar, & Steven L. Rideout, Virginia Polytechnic Institute and State University. Edamame (*Glycine max* (L.) Merr.) has increasing demands from consumers in the United States. Currently, the vast majority of edamame is imported from Asia. As part of a research team at Virginia Tech

working on improving the production of edamame in the United States, our research focuses on pest management of this crop. In 2018, we evaluated 23 varieties of large-seeded soybeans for their potential as an edible edamame crop. Key insect pests included a complex of lepidopteran pests, soybean aphid, stink bugs, potato leafhopper, and Mexican bean beetle. In 2019 I will be focusing my research on the differences among edamame varieties in pest densities and injury by insect and diseases, evaluating and refining a multi pest scouting program, determining the effects of the brown marmorated stink bug on developing edamame pods, and evaluating the efficacy of selected fungicides for control of soybean anthracnose. This work was funded by USDA-NIFA SCRI Project # PA63C42V: Developing edamame varieties for mechanized production and improved consumer acceptance to increase sustainability of the vegetable industry. Author contact: Kemper Sutton, KLSutton@vt.edu

A NEW SPECIES OF *SCIRTES* (COLEOPTERA: SCIRTIDAE) AND A REVISION OF THE GENUS FOR EASTERN USA: A SPECTACULAR EXAMPLE OF BACKYARD ENTOMOLOGY! Charles A Springer & Deborah A Waller, Old Dominion University. *Scirtes goodrichi* Springer and Waller, a new species in the family Scirtidae is described as part of a study of the aquatic beetles of southeastern Virginia. Nine specimens were collected with a light trap in the backyard of the author, and seven more were identified in museum specimens from South Carolina. Two species, *Scirtes ovalis* Blatchley 1924 and *S. piceolus* Blatchley 1924, are synonymized with *S. tibialis* Guerin 1843. *S. tibialis* and *S. orbiculatus* (Fabricius) 1801 are redescribed using defining characters that distinguish them from each other and from *S. goodrichi*. These characters include color, mandibular tooth, prosternal process, elytral convexity, body shape, and male and female genitalia. Distributions are described for the three species, which are sympatric in the type locality of *S. goodrichi*, Norfolk, Virginia. This study demonstrates the need for more critical examination of local species and museum specimens to identify unrecognized species which are increasingly confronted by the biodiversity crisis. Author contact: Charles Springer, bispinatus@cox.net.

BROWN MARMORATED STINK BUG (*HALYOMORPHA HALYS*) ASSOCIATION WITH INDUSTRIAL HEMP. Mika K. Pagani, Kadie E. Britt & Thomas P. Kuhar, Virginia Polytechnic Institute and State University. Industrial hemp is gaining momentum in interest for its various sustainable and medicinal benefits. It's a common misconception that industrial hemp is immune and resistant to pest pressure. Currently, there are only anecdotal observations relating to damage from insect pest pressure and their effects on industrial hemp yield. Studies are necessary to definitively identify the common regional agricultural pests which may pose a threat to the crop. In 2017, hemp field plots from several locations in Virginia were first sampled for insects and their damage. Several insect species were commonly encountered on hemp plants, including the brown marmorated stink bug (*Halyomorpha halys*). Effects of damage to hemp plants from this insect are unknown, so studies were initiated in 2018 to investigate further. Bugs were caged in varying densities for several weeks on seed heads of grain variety industrial hemp in field plots to document damage appearance and yield effects. Seeds were removed from plants in the laboratory, counted, and weighed to assess differences between treatments. In another study, bugs were reared on hemp seed heads

in a lab setting from the second instar to adulthood. We found that bugs developed successfully to adulthood. Results from both studies have been analyzed and will be presented. (Supported by: Virginia Academy of Science & Fralin Undergraduate Research, VA Polytechnic Inst. & State Univ.). Author contact: mika396@vt.edu

BROWN STINK BUG (*EUSCHISTUS SERVUS*) MANAGEMENT THRESHOLDS IN FIELD CORN. Tim B. Bryant & Sally V. Taylor, Virginia Polytechnic Institute & State University. In 2016 and 2017, large numbers of brown stink bugs, *Euschistus servus* (Say) (Hemiptera: Pentatomidae), were found in maize, *Zea mays* L. (Poales: Poaceae), research plots with subsequent reductions of grain yield in eastern regions of Virginia. It is unclear what level of infestation during what period of time in maize development will cause economic injury to grain yield. While previous research has shown a reduction in maize yield from herbivory during both seedling development (VE-V6) and grain fill (R1), no research-based thresholds exist for managing stink bug populations in southeastern Virginia maize. Field experiments were conducted in Suffolk, Virginia in 2018 to determine 1) if infestations during seedling development or during grain fill have a greater impact on grain yield and 2) the infestation levels that result in economic injury at each of these growth stages. Results indicate that stink bug infestations of less than 1 bug/plant during seedling corn development (V2) do not cause a significant decrease in early maize growth or the grain yield. Reproductive corn at stage R1 can also tolerate up to 3 bugs/plant without a significant decrease in grain yield, however this feeding may reduce grain quality. These results suggest that the most important time period for stink bug management in corn, is earlier in reproductive development than previously found in the literature but grain quality reduction may persist through later stages. Author contact: btim2@vt.edu

INSECT PEST EFFECTS ON INDUSTRIAL HEMP. Kadie E. Britt & Thomas P. Kuhar, Department of Entomology, Virginia Polytechnic Institute and State University. Industrial hemp is a reemerging crop to United States agriculture. Due to the crop's prohibition throughout the large part of the past century, there is little scientific information available regarding crop production and management, and no information about hemp pest management in Virginia. Thus, an industrial hemp pilot program was initiated in Virginia in 2016. In 2017, hemp field plots from several locations in Virginia were sampled for insects and their damage. Several insect species were commonly encountered on hemp plants, including corn earworm (*Helicoverpa zea*), which appeared to cause the most damage to hemp seeds and warranted future IPM research. A field study was initiated in 2018 to assess the effects of insect feeding on yield of grain variety industrial hemp. Hemp plants were manually defoliated in the field at levels of 0%, 25%, 50%, and 75% to simulate insect leaf feeding on three specific dates: 20, 40, and 60 days post planting. We found that yield was not affected by any amount or timing of leaf area removal from plants. An additional study used insecticides to selectively control insect pests from feeding on hemp, including plant feeding bugs, larval lepidopterans, and all insects. We found that insecticide treatment had no effect on overall yield of grain variety hemp. Author contact: kadieb@vt.edu.

MARGINED LEATHERWING (COLEOPTERA: CANTHARIDAE) BEHAVIOR AND ACTIVITY THROUGHOUT DAYLONG OBSERVATION PERIODS. Katlyn A. Catron & Thomas P. Kuhar, Virginia Polytechnic Institute & State University. Behavior of individual insects and interactions with conspecifics are often overlooked aspects of insect biology. Beetles in the genus Chauliognathus have been observed guarding nectar-producing inflorescences and fighting with conspecifics over these resources in Central and South America. To determine if North American Chauliognathus marginatus exhibit these or similar behaviors, adult beetles were observed on a variety of wildflowers over 8- to 10-hour periods throughout the summer of 2018. Beetle behavior and interactions were recorded hourly. The most common interaction between beetles was mating, with almost no instances of aggression or resource guarding among beetles. Individuals also engaged in traveling, preening, and resting behaviors throughout the day. Significant relationships existed between time of day, weather conditions, and beetle activity. Future work will address behavioral differences between the beetle sexes and the relationships between host plant and behavior type. (Supported by USDA Southern Sustainable Agriculture Research and Education [SARE] Grant). Author contact: Katlyn Catron, kamos@vt.edu.

Posters

EFFECTS OF FOUR SELECTIVE INSECTICIDES ON SQUASH BUG, *ANASA TRISTIS* (HEMIPTERA: COREIDAE), AND ITS PRIMARY PARASITOID, *GRYON PENNSYLVANICUM* (HYMENOPTERA: SCELIONIDAE). Sean M. Boyle, James M. Wilson, & Thomas Kuhar, Virginia Polytechnic Institute and State University. The squash bug, *Anasa tristis* DeGeer (Hemiptera: Coreidae), is an endemic pest species of the Americas that feeds on plants in the family Cucurbitaceae with a preference for squash and pumpkins. Currently, the most widely adopted strategy for squash bug management is chemical control. However, these chemical tactics mainly utilize broad spectrum insecticides which can have deleterious side effects to non-target organisms as well as promote secondary pest outbreaks. For this reason, more IPM-compatible insecticides and other management techniques are needed to mitigate these negative ecological consequences. We conducted laboratory bioassays to assess the efficacy of several selective hemipteran-specific insecticides on squash bugs and their key natural enemy, egg parasitoid *Gryon pennsylvanicum* Ashmead (Hymenoptera: Scelionidae). Flonicamid, flupyradifurone, pyrifluquinazon, and sulfoxaflor were used as the selective insecticide treatments while λ-cyhalothrin was included as a broad spectrum pyrethroid treatment. In the *A. tristis* nymph bioassays, none of the four selective insecticides provided effective control (> 50% mortality) after 48 hrs. Comparatively, flonicamid, flupyradifurone, and pyrifluquinazon were found to have minimal toxicity to adult *G. pennsylvanicum*. In both insects, λ-cyhalothrin treatments resulted in high mortality (> 90%). Although our four selective insecticides proved ineffective for controlling squash bug, their lower toxicity to *G. pennsylvanicum* supports their application as IPM-compatible chemical controls for other cucurbit pests such as aphids and whiteflies. Author contact: seanboyle@vt.edu

NEW INVESTIGATIONS OF SPOTTED LANTERNFLY IN VIRGINIA. Andrew C. Dechaine[1], Douglas G. Pfeiffer[1], Thomas P. Kuhar[1], Scott M. Salom[1] & Tracy C. Leskey[2], [1]Department of Entomology, Virginia Polytechnic Institute and State University, [2]USDA-ARS, Appalachian Fruit Research Station, Kearneysville, West Virginia. *Lycorma delicatula* (spotted lanternfly) is a new invasive Fulgoridae species native to China that was first detected in Winchester, VA in January 2018. During that year, *L. delicatula* expanded its range from one square mile to 18 square miles. *L. delicatula* is a phloem feeder and has been reported to feed on over 70 host plant species and has the potential to be an economically important pest to fruit trees, vineyards, and forests throughout the state. In 2019, *L. delicatula's* phenology and host plant preference will be recorded weekly from early April to November within the infestation zone in Winchester, VA. During the winter of 2019-2020, surveys will be conducted in Winchester to determine the vertical distribution of *L. delicatula* egg masses on *Ailanthus altissima* (tree-of-heaven) via visual estimation and a physical count on felled trees. *L. delicatula* phenology and egg mass distribution will aid in the development of integrated pest management strategies that will ultimately help control the spread and impact of this insect. U.S. Forest Service Cooperative Forest Health project PV6VVEDP. Author contact: Andrew Dechaine, dechaine@vt.edu.

THE ANT (HYMENOPTERA: FORMICIDAE) FAUNA OF VIRGINIA'S REMNANT PYROPHYTIC COMMUNITIES. Kal Ivanov & Liberty Hightower, Department of Recent Invertebrates, Virginia Museum of Natural History, Martinsville VA, 24112. Prior to European settlement, longleaf pine (*Pinus palustris* Mill.) forests stretched across the southern United States from Virginia in the north, south to Florida and westward to Texas. Land clearing, logging, and the interruption of natural fire regimes have greatly reduced the extent of these communities, making them one of the most threatened ecosystems in the United States. Although these pyrophytic communities host a remarkable diversity of plant and animal life, little is known about the arthropods associated with them. Between 2015 and 2018, we surveyed ants in three protected southeastern Virginia sites in the early stages of long leaf pine restoration. Overall, we collected 54 ant species in 24 genera and 6 subfamilies. Eight of these species represent new Virginia records, three are northward range extensions, and one, *Solenopsis invicta* Buren, is an invasive species. Virginia's sandhill habitats represent unique "islands" allowing for the establishment and continued persistence of ant taxa associated with deep sand deposits many of which are only rarely encountered in the state. Despite being rather uncommon in Virginia, these unique and fragile habitats harbor nearly one-third of the ant species known from the state at present. Author contact: kal.ivanov@vmnh.virginia.gov.

Environmental Science

(Not Available)

Medical Sciences

CAFFEINE CONSUMPTION ATTENUATES THE CARDIOPROTECTIVE EVENTS OF THE DIVE REFLEX. Vhuthuhawe T. Madzinge, Dept. of Biology and Chemistry, Liberty Univ. The dive response promotes bradycardia (increased vagal tone), blood shift, splanchnic circulation, increased HRV (heart rate variability), and peripheral vasoconstriction through the activation of cutaneous facial thermoreceptors innervated by the trigeminal nerve fibers following facial immersion in cold water. A quasi-experimental study of 84 healthy participants was conducted utilizing HRV, variations in beat-to-beat intervals, to assess the autonomic nervous system (ANS) function during the dive response under the influence of caffeine (a sympathomimetic). We hypothesized that caffeine would decrease HRV (the standard deviation of normal RR intervals - SDRR), which evaluates the balance between the parasympathetic (the root mean square of RR intervals - RMSSD, and high-frequency -HF) and sympathetic (low-frequency – LF, and LF/HF ratio) nervous system during tidal breathing, breath holding, and submersion in 14°C water. The second trial was run 30-45min after the consumption of 200mg of Equate Stay Awake Caffeine. The main effect of caffeine on SDRR ($F(1,83)=0.618$, $p=0.434$), RMSSD ($F(1,74)=2.41$, $p=1.148$), LF ($F(1,49)=1.115$, $p=0.296$), and HF ($F(1,49)=0.626$, $p=0.433$) was not statistically significant, as opposed to LFHF ratio ($F(1,74)=4.023$, $p=0.049$). The main effect of the dive response on SDRR ($F(1,83)=28.778$, $p<0.0005$), RMSSD ($F(2,148)=10.879$, $p<0.0005$), LF ($F(1,49)=12.705$, $p=0.001$), HF ($F(1,49)=11.490$, $p=0.001$), and LFHF ratio ($F(1.471,108.889)=26.504$, $p<0.0005$) was statistically significant. In addition, SDRR ($F(1.467.121.799)=4.977$, $p=0.016$), RMSSD ($F(1.410,111.382)=3.730$, $p=0.0420$) and LFHF ratio ($F(1.428,105.701)=7.089$, $p=0.004$) exhibited a statistically significant interaction between caffeine and the dive response. These results indicate that although HRV increases during the dive response, the consumption of 200mg of caffeine diminishes this increase and can attenuate the cardioprotective properties of the dive response. Therefore, caffeine should not be taken prior to a dive due to its negative impact on HRV. This research is made possible in part by support from the Liberty University's Center for Research & Scholarship Provost Research Initiative grant awarded to Dr Ben Kalu. Author contact: vmadzinge@liberty.edu.

THE EXPRESSION OF CONNEXIN-43 BY DENDRITIC CELLS IS REQUIRED TO MAINTAIN $CD4^+$ $FOXP3^+$ REGULATORY T CELL POPULATION. Caroline T. Miller, Lauren M. Browning & Piotr J. Kraj, Department of Biological Sciences, Old Dominion University. Immunosuppressive $Foxp3^+$ regulatory T cells (T_R) are a subset of $CD4^+$ T cells that maintain homeostasis of the immune system. They have been shown to be sustained by the interaction between Major Histocompatability Complex (MHC) present on antigen presenting dendritic cells and the T Cell Receptor (TCR) expressed on T_R cells that is specific for the MHC with antigenic peptide. Here we show that in addition to MHC/TCR interaction, Connexin-43 (Cx43) expression by dendritic cells is required to maintain the T_R population. CD11c+ dendritic cells represent a major subset of antigen presenting cells. We have observed that mice that lack Cx43 expression on CD11c+ dendritic cells have a lower percentage of T_R cell population, which in turn also have a lower level of Foxp3 expression. These mice showed increased incidence of

dermatitis as they age, even though we show that their dendritic cells can efficiently present antigen to naive T cells. The decrease in the presence of T_R cells was associated with an altered phenotype of these cells, demonstrated by lower expression of CD39 and higher expression of CD73,which are ectonucleotidases involved in its immunosuppressive function. We propose that the presence of Cx43 on the surface of dendritic cells is required for effective communication between T_R cells and dendritic cells so as to sustain T_R cell proliferation and Foxp3 expression. Author contact: cmill012@odu.edu.

Posters

THE NEUTRALIZING ACTIVITY OF HUMAN SERA ON CYTOMEGALOVIRUS SHED IN URINE. Lonneke L. Palmer[1], Li He[2], & Michael A. McVoy[2], [1]John Tyler Community College and [2]Department of Pediatrics, Virginia Commonwealth University. Cytomegalovirus (CMV), a member of the *Herpesviridae*, is responsible for about three percent of congenital abnormalities in the United States. Despite being such a threat to one of the nation's most vulnerable populations, an efficacious vaccine has yet to be produced and many remain ignorant to the existence and/or potential of this virus. The urine and saliva of a person infected with CMV have been identified as the main infectious materials by previous studies due to the abundance of virions in these bodily fluids and are perceived to be contracted by others by the oral route. Therefore, the ideal vaccine should garner defense against this virus starting in the mouth. To do this, an adequate number of neutralizing antibodies need to be present in the saliva, oral submucosa, or oral lymphatics. However, our group recently found that, in contrast to CMV produced in cell culture, CMV shed in the urine of infected newborns or toddlers is highly resistant to neutralization by monoclonal antibodies or polyclonal antibodies purified from the blood of CMV-positive (immune) donors (*e.g.*, CytoGam). The current experiment was designed to determine if antibodies in the context of human sera (as opposed to purified IgG) can neutralize CMV in urine obtained from infected babies. CytoGam as well as sera from one CMV-negative (naive) and two CMV-positive adults were serially diluted and each dilution was combined with CMV-positive urine and incubated for an hour at 37°C. Mixtures were then introduced into wells of a 96-well plate containing confluent MRC-5 fibroblasts, incubated for 7 days, and stained for CMV Immediate Early proteins by immunofluorescence. At a 1:2 final concentration CMV-positive and CMV-negative sera had neutralizing activities that were presumably not antibody mediated. At a 1:6 final concentration the two CMV-positive sera partially neutralized infectivity of CMV in urine but CMV-negative serum did not. CytoGam at 640 µg/ml alone or combined with negative serum (diluted 1:6) had no activity. These results suggest that urine CMV is sensitive to non-specific antiviral factors in serum at high concentrations and that CMV-specific serum neutralizing antibodies can partially overcome urine CMV's resistance to antibody neutralization, but again only at high serum concentrations. Factors in CMV-negative serum failed to enable the neutralizing activity of CytoGam, but the concentration tested may have been inadequate. CMV is able to live in the body for a life-time without suspicion in healthy individuals but can be very problematic for the young, the elderly, and those suffering from a weakened immune system. To formulate an impactful vaccine for this virus, it is important to understand

how, where, and when antibodies are able to effectively neutralize the virus's potential in vivo. (Supported by NIH, VCU Bridges to the Baccalaureate R25GM102795). Author contact: michael.mcvoy@vcuhealth.org.

ADVANCEMENT OF THE IN-VITRO IDIOPATHIC PULOARY FIBROSIS DISEASE MODEL THROUGH ISOLATION OF SENESCENT AND ACTIVE FIBROBLAST PHENOTYPES. Brieann H. Sobieski[1], Luis R. Rodriguez[1], Steven D. Nathan[2] & Geraldine Grant[1], [1]Dept. of Biol., George Mason Univ. [2]Adv Lung Disease and Transplant Program, Inova Heart and Vascular Institute. Idiopathic Pulmonary Fibrosis (IPF) is a heterogenous disease for which there is no known cure, resulting in more than 40,000 deaths annually. Due to the heterogenous nature of IPF, the senescent phenotype is one of many in the IPF lung. Explant isolation is the primary method for isolating fibroblasts, which may preferentially select the senescent phenotype. We have previously demonstrated a novel isolation methodology, differential binding, that we hypothesize selects for an active non-senescent phenotype. Our focus in this study is therefore to investigate cell senescent markers in two fibroblast populations isolated by different techniques. IPF (n = 10) lung transplant tissue was isolated from each sample using both isolation techniques. DNA and RNA were extracted using the Wizard™ Genomic DNA purification Kit (Promega) and Qiagen RNeasy kit (Qiagen). Markers of senescence (p16 and p21) were quantified by qPCR. Explant fibroblasts demonstrated an increase in p16 and a decrease in p21 expression. Further investigation revealed that TGF-ß1 signaling was inducing increased p21 expression in fibroblasts isolated via differential binding. These results indicate the successful isolation of a cell type which is both active and non-senescent. Designing experiments including fibroblasts isolated via explant and differential binding techniques may yield a more accurate *in-vitro* model for the IPF lung. Supported by: INOVA Lung Fund and GMU OSCAR). Author contact: Brieann Sobieski, bsobiesk@gmu.edu.

Natural History and Biodiversity

HISTOLOGICAL COMPARISON OF PARASITE INDUCED PATHOLOGY IN MALE MORPHOTYPES OF BLUEGILL SUNFISH (*LEPOMIS MACROCHIRUS*). Candace E. Ashworth & Michael R. Zimmermann. Shenandoah University. Bluegill sunfish (*Lepomis macrochirus*) are a sexually dimorphic North American sport fish possessing multiple male morphotypes that differ in territoriality, diet, and behavior. The larger α-males invest heavily in courtship and parental care, while the subordinate β-males partake in mating strategies involving sneaking or mimicking behaviors, resulting in significantly less gene transmission than α-males. This raises the question of why an alternative male morphotype is necessary in *L. macrochirus* populations, given its low reproductive success. Previous studies regarding parasitism in *L. macrochirus* have not accounted for these distinct morphotypes, but this study investigated whether differences in parasite loads and host adaptive immunity contribute to the maintenance of alternative male morphotypes within *L. macrochirus* populations. Over 1,500 *L. macrochirus* were collected from 14 lakes and ponds in northwestern Virginia and examined for parasite infections. Histological sectioning of the visceral

organs of several *L. macrochirus* was conducted to observe potential differences in the host immune response to parasites. Comparisons of α-male and β-male tissue may demonstrate different patterns of humoral or cell-mediated responses to parasite infection, necessitating the presence of an alternative male morphotype within *L. macrochirus* populations. Differences between the immune responses of the male morphotypes may indicate that the parasite load may negatively impact α-males, attributing to the maintenance of a male β-morphotype with low reproductive success and alternative mating strategies. This is the first evidence of the parasitism differences between morphotypes having varying impacts on health, which may be important to the maintenance of larger, healthier *L. macrochirus* fisheries. (Supported by: Mednick Fellowship Award from the Virginia Federation of Independent Colleges). Author contact: Candace Ashworth cashwort16@su.edu.

UPPER THERMAL LIMITS VARY AMONG AND WITHIN NATIVE BEE SPECIES IN RELATION TO SEASON, VOLTINISM, AND NEST TYPE. Kálmán K Csigi[1], Salvatore J Agosta[2] & Karen M Kester[1]. [1]Department of Biology and[2] Center for Environmental Studies, Virginia Commonwealth University. Native bees are recently gaining attention for the essential pollination and ecosystem services they provide. These services may be threatened by warming temperatures associated with global climate change. Voltinism - the number of generations produced annually- is an important factor in determining the thermal conditions experienced during development and while foraging. Hypothetically, upper thermal limits (UTLs) of adult bees should reflect adaptations to temperatures experienced during development and foraging. Over the foraging season in 2018, 97 native bee species were collected in and around the City of Richmond. UTLs were quantified using dynamic ramping trials to determine the fatal knockdown point (FKP). Univoltine species that emerged later in the season had higher FKPs than univoltine species emerging earlier in the season. Later generations of multivoltine species had higher FKPs than earlier generations. FKPs recorded for all species were higher than historic air temperatures of the study region, but within several degrees of the highest recorded maximum daily temperature. While native bees still face a potential myriad of other issues brought on by climate change, observed increases in FKP over the season suggest that these essential insects have a limited physiological capacity to adapt to a warming climate. (Supported by VCU Rice River Center Graduate Research Scholarship). Author contact: Karen Kester, kmkester@vcu.edu.

ANALYZING THE FLIGHT PATTERNS AND BEHAVIOR OF DRAGONFLIES ENGAGED IN AERIAL TERRITORY BATTLES. Brandon T. Hastings & Brandon E. Jackson. Longwood University. It has previously been determined that dragonflies who occupy the most suitable territory within a habitat have a higher muscle capacity than those who occupy poor territories, but it is unknown how this increased muscle capacity relates to their flight patterns. This study examined the flight patterns of dragonflies engaged in aerial territory battles to investigate differences in maneuverability. 3D video data of dragonflies interacting in a natural habitat was analyzed for interacting (<0.5 m apart) and non-interacting flights. Non-interacting dragonflies showed higher linear velocities and accelerations, while interacting dragonflies showed higher angular velocities. With further data collection, we can

categorize the winners and losers of these territory battles and provide a link between flight maneuverability and muscle capacity in dragonflies. Author contact: Brandon Hastings, brandon.hastings@live.longwood.edu.

INTRASPECIFIC VARIATION IN THE SECRETION AND MORPHOLOGY OF THE SCENT GLANDS OF A NETROPICAL COSMETID HARVESTMAN. Amanda C. Albert, Victor R. Townsend, Jr. & Maynard H. Schaus. Dept. of Biol., Virginia Wesleyan Univ. Intraspecific variation in the use of chemical defenses by cosmetid harvestmen has not been previously investigated. In this study, we examined variation in the emissions from the scent glands and the morphology of the ozopores of *Erginulus clavotibialis*. Most individuals did not secrete when seized by leg IV, however, when the body was grasped firmly with forceps, 76% of the harvestmen (n = 96) responded by releasing enteric fluid (clear, no odor) or secretions from the scent glands (reddish-brown, distinct odor), most commonly in the form of globules near the ozopores. Adults and penultimate nymphs rarely (less than 5% of all trials) exhibited leg dabbing, an unusual defensive behavior generally associated with cosmetid harvestmen. Males released enteric fluid significantly more than females or nymphs. Nymphs emitted secretions from scent glands at a significantly greater frequency than males or females. The morphology of the ozopores varies between adults and nymphs but not between males and females. The openings of the ozopores of nymphs are circular and are not obscured by the dorsal posterior process of coxa I and the dorsal anterior process of coxa II. In contrast, adults have subtriangular ozopores that are difficult to observe without dissection because they are partially blocked by the dorsal processes of coxae I and II. Author contact: Victor Townsend, vtownsend@vwu.edu.

SEM-BASED STUDY OF FECAL SAMPLES FROM A NEOTROPICAL COSMETID HARVESTMAN. Sara A. Wiltshire, Victor R. Townsend, Jr. & Maynard H. Schaus. Dept. of Biol., Virginia Wesleyan Univ. In contrast to the flattened structure of adults, cosmetid nymphs have elongate pedipalps adorned distally with a delicate pretarsus. Relatively little is known about the diet of these harvestmen or any ontogenetic changes in feeding habits that reflect differences in pedipalp morphology. Observations of individuals feeding upon fruit and termites revealed that adults use their pedipalps to grasp and manipulate food items, whereas the nymphs rely exclusively upon their chelicerae while feeding. We used scanning electron microscopy (SEM) to examine approximately 30 fecal samples from individuals of *Erginulus clavotibialis*, a common cosmetid harvestman in Belize. Fecal material included samples from multiple adults (males and females) and several penultimate nymphs. As an aid to the identification of prey items, we also examined fecal samples collected from captive *Leiobunum formosum* that were fed specific diets of baby food, mushrooms, dog food, apples or termites. Our results suggest that both nymphs and adults are omnivores and that they consume a variety of food items. From the fecal samples, we identified bacteria, plant material (tissue and pollen), fungal hyphae, annelid setae, lepidopteran scales, a hymenopteran ovipositor, and legs, setae, eyes, and body parts of several types of arthropods. We did not find any major differences in diet between nymphs and adults. Author contact: Victor Townsend, vtownsend@vwu.edu.

INTRASPECIFIC VARIATION IN THE DISTRIBUTION OF ELEMENTS IN THE CHELICERAE AND CLAWS OF A NEOTROPICAL COSMETID HARVESTMAN. Shelby A. Wright, Victor R. Townsend, Jr. & Sara A. Wiltshire. Dept. of Biol., Virginia Wesleyan Univ. In many arthropods elements that are used to mineralize and harden the cuticle include Ca (shells of crustaceans), Fe (ovipositors of insects), and Zn (jaws of annelids). In this study, we used energy dispersive spectrometry (EDS) to investigate the elemental composition of the exoskeleton of the cosmetid harvestman *Erginulus clavotibialis*. We examined samples from alpha males, beta males, females and penultimate nymphs (n = 3 for each). Spectra were collected at each sample site using accelerating voltages of 10 kV (surface) and 20 kV (subsurface). Our results indicate that the composition of the exoskeleton varies sexually, ontogenetically and between different regions of the body. The most common elements (>1%) were Al, Cl, Ca, Fe, S and Si. Spectra collected at 10 kV, generally had higher levels of Al, Cl, and S. In contrast, spectra collected at 20 kV had higher relative percentages of Ca. We found considerable amounts of Si at 10 kV, but only in association with the tubercles of femur IV and the pedipalp. We also found the highest percentages of Fe in the chelicerae. Nymphs had the lowest relative percentages of Al, Fe and S at 10 kV. The results of our study that harvestmen do not use Zn in their exoskeleton. In addition, we did not regularly observe Mn. Author contact: Victor Townsend, vtownsend@vwu.edu.

INTERSPECIFIC, ONTOGENETIC AND SEXUAL VARIATION IN OZOPORE MORPHOLOGY AMONG COSMETID HARVESTMEN. Victor R. Townsend, Jr.[1], Saoirse Teevan-Kamhawi[2] & Devin Calpo[2]. [1]Dept. of Biol., Virginia Wesleyan Univ. and [2]Maury High School. The ozopores of cosmetid harvestmen rest upon lateral projections of the carapace, have simple or highly reduced channels, and are partially obscured by enlarged dorsal processes associated with coxae I and II. Relatively little is known about interspecific variation in ozopore morphology among these harvestmen. In this study we used SEM to examine the ozopores of males and females of nine species as well as those of antepenultimate nymphs for two species. For adults, we found differences between species in the shapes of the ozopores, the morphology of the dorsal and lateral channels, and the relative size, shape and armature of the dorsal posterior process (dpp) of coxa I and the dorsal anterior process (dap) of coxa II. Our observations suggest that the morphology of the coxal processes could be sources for systematic characters in future phylogenetic studies. We observed ontogenetic differences but relatively little intersexual variation in the morphology of the ozopore. Nymphs have ozopores that are generally more oval than those of adults with an opening that is also less obstructed, if at all, by the dorsal coxal processes. These morphological differences suggest that nymphs may use scent gland secretions in a manner different from that of adults. Author contact: Victor Townsend, vtownsend@vwu.edu.

FECUNDITY OF NATIVE VIRGINIA LONGLEAF PINE AT JOSEPH PINES PRESERVE, SUSSEX COUNTY VIRGINIA. Phil Sheridan, Noelle Delaney Stevens & Emily Vollmer. Meadowview Biological Research Station. Longleaf pine reaches its northern limit in Virginia and is a keystone species in an ecosystem covering millions of hectares in the southeastern U.S. Large-scale longleaf pine ecosystem restoration efforts are underway at the federal, state, and local level and are the largest forest ecosystem

restoration effort in North America. Our research has provided evidence that the Virginia longleaf pine genotype is superior for in-state planting and restoration because of higher survival rates and faster growth. Other researchers have found that Virginia longleaf pine has a higher water use efficiency than southern populations. We have also found in a previous research project that the Virginia longleaf pine genotype is able to produce female cones at an earlier age than other longleaf pine provenance. In this study, we were able to replicate and validate the ability of Virginia longleaf pine to reproduce at an earlier age at the Joseph Pines Preserve in Sussex County, Virginia. Cone production did not correlate with either height or stem diameter. The reason for the ability of Virginia longleaf pine to reproduce at an early age awaits further investigation. Author contact: meadowview@pitcherplant.org.

LONGLEAF PINE HABITAT RESTORATION RAISES GROUNDWATER LEVELS. Phil Sheridan, Noelle Delaney Stevens & Emily Vollmer. Meadowview Biological Research Station. We had observed that pitcher plant bogs seemed to be getting wetter as we proceeded with longleaf pine habitat restoration at the Joseph Pines Preserve in Sussex County, Virginia. Habitat restoration involved large-scale (multi-hectare) mulching, chipping, burning, and herbicide spraying of dense stands of 20-year old hardwoods and pines. We hypothesized that conversion of a dense hardwood/pine stand to a longleaf pine savanna would raise groundwater levels. A hydrologic study was conducted by a graduate student and calculations indicated that our habitat restoration methods resulted in a 25% reduction in evapotranspiration, potentially leading to higher groundwater levels. In 2016 a clear-cut logging operation was performed on part of the watershed at Joseph Pines Preserve and we were able to test the effects of this habitat restoration method on groundwater levels. The clear-cut of the forest raised ground water levels as predicted, supporting our initial hypothesis. Ground water levels rose by as much as 15 cm and the effect was greatest the closer the measurement was made to the clear-cut. The net effect was to increase groundwater by seven million liters on a 10-hectare watershed. Author contact: meadowview@pitcherplant.org.

MICROBIAL ASSEMBLAGES AS DRIVERS FOR CRAYFISH ECTOSYMBIOTIC BRANCHIOBDELLIDAN COMMUNITIES. Matthew Cooke, Gabriel Hooper, Luke Fisher, John Hoverson, Kaleb Bohrnstedt, Mark Fischer, Nathan Edmondson, Thomas Kepler, Matthew Becker & Kyle Harris, Dept. of Biology and Chemistry, Liberty University. Crayfish participate in a dynamic cleaning symbiosis with branchiobdellidan worms (BW), which consume bacteria from the carapace and gill filaments of crayfish. In our first experiment, we inoculated a test group of crayfish with four BW each and removed all BW from the control group. We hypothesized that BW presence would alter the host's dissolved oxygen (DO) uptake and the microbial community assemblages (MCA) on the carapace. No significant effect on the DO uptake was seen. We found that taxa of bacterial isolates differed between the two groups with no observed overlap. In our second experiment, we collected swabs from crayfish with varying loads of BW in a stream continuum. Different microbial samples were collected from the carapace of the crayfish, water, and sediment. These were collected in first and second order streams. 16S gene sequencing was utilized in conjunction with QIIME 2 to analyze the microbial swabs. The MCA alpha diversity was compared between stream

orders, sample types, and number of BW. QIIME2 analysis revealed significant differences in the alpha diversity between sample types ($p < 0.001$). There was no significant difference in MCA from different stream orders or from crayfish with and without BW. However, potential dissimilarity was noted when crayfish samples were separated into cohorts based on the number of BW present. (Supported by: Provost Research Initiative (PRI) Grant, Liberty University). Author contact: Kyle Harris, kjharris@liberty.edu.

Posters

CORRELATION BETWEEN MORPHOLOGY, PREDATOR ESCAPE PERFORMANCE, AND MATERIAL PROPERTIES OF THE VERTEBRAE IN YELLOW PERCH, *PERCH FLAVESCENS* (*PISCES: PERCIDAE*): INTRASPECIFIC DIVERGENCE IN FUNCTIONAL DESIGN. Takashi Maie, Lilli E. Altenburg & Douglas B. Dickerson, Dept. of Biol, University of Lynchburg. Many teleosts exhibit intraspecific variation that often correlates with differences in resources and habitat. We evaluated the extent of variation in *Perca flavescens* from two ecologically distinct lakes by examining body morphology, kinematics and performance of predator escape response, and material properties of the vertebrae. The fish from the mining-influenced lake (with high calcium bioavailability, low pH, and low visibility) showed greater angular velocity and acceleration during the escape response than the fish from the spring-fed lake (with low calcium, high pH, and high visibility). The differences in escape kinematics and performance appear to be correlated with body morphology and material properties of the vertebrae. Compared to the fish from the spring-fed lake, the fish from the mining-influenced lake showed shorter and deeper body with a wider caudal peduncle, perhaps contributing to the maneuverability rather than the ability to cruise. The vertebrae in the fish from the mining-influenced lake showed greater strength and Young's modulus than those in the fish from the spring-fed lake, contributing to the greater recoilability of the vertebral column. In the predator-prey interaction, perhaps occurring at the different proximity, body morphology and vertebral material properties change in the way that these components of locomotor design in *P. flavescens* contribute to enhance their escape performance; therefore, fitness of the population. Author contact: Takashi Maie, maie.t@lynchburg.edu.

INTERSPECIFIC VARIATION IN THE PREVALENCE AND INTENSITY OF LARVAL ECTOPARASITIC MITES UPON A NEOTROPICAL COSMETID HARVESTMAN. Elizabeth A. Roberto, Victor R. Townsend, Jr. & Maynard H. Schaus. Dept. of Biol., Virginia Wesleyan Univ. Larval erythraeid mites are common ectoparasites of terrestrial arthropods, including harvestmen (Order Opiliones). In this study, we investigated intraspecific variation in prevalence, intensity and attachment sites of larval mites (*Leptus* sp.) infesting *Erginulus clavotibialis*, a cosmetid harvestman from Belize. We did not observe any significant sexual and ontogenetic differences in the prevalence or intensity of infestation. Across three sites, the prevalence ranged from 18-71% and the intensity varied from 2-4 larval mites per host. Larval mites exhibited a non-random distribution with respect to attachments sites, with significantly more mites occurring on femur IV. Larval mites were absent from the tarsi of the walking legs and

were rarely observed attached to the pedipalps or chelicerae of the harvestmen. An SEM-based examination of attachment sites revealed that the mites prefer areas on the host that have been previously used by other larval mites (as evidenced by the presence of abandoned cones). In addition, the distal tips of the chelicerae of the mites are adorned with numerous processes (cilia or stereocilia) that may aid in feeding upon the hemolymph and tissues of the host. Author contact: Victor Townsend, vtownsend@vwu.edu.

FORCE AND ENDURANCE OF ADHESION IN WATERFALL-CLIMBING GOBIES. Samuel T. Vickers & Takashi Maie, Dept. of Biol, University of Lynchburg. Many amphidromous sicydiine gobies exhibit rock-climbing behavior during upstream migration along rivers and streams. Using the pelvic sucker, formed by fused pelvic fins, these gobies generate suction for adhesion on the climbing surface. By measuring performance variables that correlate to successful rock-climbing capability, we evaluated suction force for adhesion and fatigue time during sustained adhesion on the climbing surface in a power-burst waterfall-climbing goby, *Sicydium punctatum*, from Dominica, West Indies. An adult *S. punctatum* individual with body mass of 8.27 g generated the maximum suction force of 0.208 N, which is calculated to be supporting approximately 2.56 times body mass. This individual exhibited the fatigue time of 31.4 seconds. Compared to the scaling pattern of fatigue time known for waterfall-climbing gobies (from *Sicyopterus japonicus* with $\mathrm{LogT}_{\mathrm{fatigue}} = -8.48\mathrm{x}(\mathrm{LogBM}-0.58)^2+1.71$), *S. punctatum* might have a higher endurance capacity in its pelvic muscles. Author contact: Samuel Vickers, vickers_st@lynchburg.edu.

Psychology

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THE INFLUENCE OF GREEK LIFE ON ALCOHOL EXPECTANCIES. Mary Doberneck[1], Jalen Ragsdale[1], Melissa Colangelo[1], & Abby L. Braitman[1,2], [1]Old Dominion University, [2]The Virginia Consortium Program in Clinical Psychology. Fraternities and Sororities are notoriously known for having high levels of alcohol consumption. The normalization of binge drinking in a specific college group as such could have impacts on the alcohol expectancies those students have. The current study examined drinking habits in participants ($N = 475$) who were 18-28 years old ($M = 19.88$, $SD = 1.71$) and had consumed at least one drink in the past 30 days. A one way ANOVA test revealed a statistically significant difference in the liquid courage subscale of alcohol expectancies, $F(3,471) = 3.59$, $p = .014$, between Greek members ($M = 15.83$, $SD = 3.32$) and non-Greek students who do not attend events ($M = 14.05$, $SD = 3.91$), $p = .003$. An LSD post hoc test also revealed that the risk and aggression subscale of alcohol expectancies was significantly higher for current Greek members ($M = 13.67$, $SD = 3.74$) than either non-members who attend Greek events regularly ($M = 11.63$, $SD = 3.85$), $p = .003$, or non-members who do not attend events regularly ($M = 10.95$, $SD = 4.03$) $p < .001$. These results show that there are differences in certain alcohol expectancies between Greek and non-Greek members. Future research should examine why the only

alcohol expectancy subscales with any significant difference are liquid courage, and risk and aggression. Author contact: Abby L. Braitman, abraitma@odu.edu.

SEX DIFFERENCES MODULATE BEHAVIORAL AND STRESS INFLUENCES ON SEROTONIN AND DOPAMINE RECEPTORS IN RAT BRAIN. W. David Knight, Joseph Picone, Susannah Garber, & Olga Lipatova, Department of Molecular Biology and Chemistry and Program in Neuroscience, Christopher Newport University. Stress differentially modulates inhibition of behavioral responses in males and females. We examined the role of striatum function in the mechanism for this behavioral sex difference. Dopamine and serotonin signaling in the dorsolateral striatum (DLS) contribute to learned habitual responses, while activity in the dorsomedial striatum (DMS) is involved in the goal-directed operant learning. Quantification of gene expression for serotonin 6 (5-HT6R) and dopamine (D1 and D2) receptors in the DLS and DMS of male and female rat brains suggested that stress induces increased dopamine signaling in the DLS of female rats compared to male rats. Stress does not induce differential response in the DMS of female or male rats. Interestingly, receptor expression in the DMS was greater in rats learning to navigate a spatial task using a goal-directed strategy compared to the rats that learned a habitual directional response. These findings are consistent with the differences in the DLS vs DMS function. The sex-specific dopaminergic and serotonergic modulations in the DLS are suggested to be potential reasons for the sex differences in habit formation and inhibition of behavioral responses. Author contact: david.knight@cnu.edu

DOES CANNABIS USE VARY BY RACE AND GENDER AMONG COLLEGE STUDENTS? Monae Porter[1], Nydesha Brown[1], Melissa Colangelo[1], & Abby L. Braitman[1,2], [1]Old Dominion University, [2]The Virginia Consortium Program in Clinical Psychology. Early studies on substance use have shown that drug use is typically at its height between late adolescence and early twenties. The purpose of the current study was to determine if cannabis use varies by race and gender. The study's sample consisted of 477 undergraduate college students, ages 18-2, attending a university in the southeastern U.S. Findings in the study revealed that cannabis use did not differ by gender, χ^2 (1) = 0.75, p = .384. However, cannabis use was found to be significantly different by race, χ^2 (3) = 7.82, p = .0498. Multiracial college students (80.0% users) were more likely than Caucasian or White (64.1% users) and Asian or Pacific Islander students (51.7% users) to have used cannabis. However, none of these groups' lifetime cannabis use differed significantly from African American or Black students (67.3% users). Future research should focus on multiracial student substance use. Author contact: Abby L. Braitman, abraitma@odu.edu.

DRINKING MOTIVES AND EXPECTANCIES: DIFFERENTIAL STRENGTH OF PREDICTION FOR ALCOHOL USE AMONG COLLEGE STUDENTS. Helen H. Smith[1], Anthony G. Ladikos[1], Melissa R. Colangelo[1], & Abby L. Braitman[1,2], [1]Old Dominion University, [2]The Virginia Consortium Program in Clinical Psychology. Alcohol expectancies and drinking motives have both been shown to be predictors of alcohol use among college students in previous research. The present study compared motives and expectancies to determine which is a better predictor of alcohol use (quantity

and frequency). These data come from a larger study funded by the NIAAA (N = 471). Two linear regressions were used to compare alcohol expectancies and motives on both quantity and frequency of alcohol consumption. Cognitive and Behavioral Impairment expectancies were found to be negatively associated with alcohol quantity (β = -0.11, p = .032), while Risk and Aggression expectancies were positively associated with quantity (β = 0.17, p = .008). As for drinking motives, both Social (β = 0.20, p =.004) and Enhancement (β = 0.15, p = .025) motives were positively associated with alcohol quantity. In terms of frequency of alcohol use, sexual expectancies were positively related to alcohol frequency (β = 0.11, p = .036), while Cognitive and Behavioral Impairment expectancies was negatively related to frequency (β = -0.17, p = .002). Lastly, drinking to cope was positively related with alcohol frequency (β = 0.13, p = .025). These results show that both alcohol expectancies and drinking motives predict alcohol use about equally. However, the study results show that social motives are the best predictor of alcohol quantity, whereas cognitive and behavioral impairment expectancies are the best predictor of alcohol frequency. Author contact: Abby L. Braitman, abraitma@odu.edu.

Structural Biology, Biochemistry and Biophysics

MICROFLUIDIC INVESTIGATIONS OF THE TEMPORAL DYNAMICS OF CASPASE ACTIVITY IN LIVING CELLS. Randall D. Reif, Dept. of Chem., Univ. of Mary Washington. Apoptosis, a process in which a cell systematically triggers its own death in response to DNA damage or external stimuli, is widely utilized in the body. Malfunction of the apoptosis process can lead to serious health problems such as cancer. There are two major pathways for the cell to undergo apoptosis: extrinsic and intrinsic. Each is dependent on the method of induction. The goal of this research project is to elucidate and compare the temporal dynamics of apoptosis in Jurkat T-Lymphocytes with respect to caspase activity, through both the intrinsic and extrinsic pathways using fluorescence microscopy. Polydimethylsiloxane (PDMS) based microfluidic devices were fabricated with a channel coated with antibodies to trap cells in a controlled environment over the course of the studied period (6 hours). The extrinsic pathway studies used anti-CD95 to capture the cells and induce apoptosis. The experiments examining the intrinsic pathway used anti-CD71 to capture the cells while they were exposed to 50 mM hydrogen peroxide to induce apoptosis. The fluorogenic caspase probe, L-bisaspartic acid Rhodamine 110 (D_2R), was used to visualize general caspase activity while a derivative of the probe ($DEVD_2R$) was used to monitor caspase-3. For the intrinsic pathway, overall caspase activity initiated from 4.3 to 5.3 hours after induction, lasting 40 to 60 minutes, while caspase-3 activity started 5.3 hours after induction and lasted 20 to 40 minutes. For the extrinsic pathway, overall caspase activity started 3.3 to 5.3 hours after induction and lasted between 1.3 and 4.6 hours, while caspase-3 activity was shown to start 5.3 hours after induction and lasted 20 to 40 minutes. This indicates that the timing of executioner caspase activation is independent of induction pathway. Knowledge of the timing of caspase activation could be helpful when designing therapies that affect apoptosis.

A WEBSITE TO AID IN TEACHING STRUCTURAL BIOLOGY TO UNDERGRADUATES. Nathan T. Wright, Dept. of Chem. and Biochem., James Madison Univ. Protein structures are frequently used in both textbooks and in lecture to demonstrate fundamental biochemical concepts. Despite structural biology's important position in the pantheon of teaching tools, undergraduate students rarely learn the tools of how these pictures are generated, or how to evaluate the validity of these structures. This is, in part, due to a lack of undergraduate-specific teaching tools on the subject. Over the past five years, our lab has sought to create accessible structural biology content. Here, we present a new website (https://osf.io/r73dc/) that allows users to access a wide variety of structural biology data, along with detailed instructions of how to analyze these data. Each experiment can be easily implemented into a biochemistry lab, and can possibly be assigned in a larger class. Instructions of how to download all free software are included. These data were all tested in a senior-level undergraduate biochemistry lab, and in every case students were able to generate publication-worthy data analysis. As this website grows, we hope to include more theory behind these modules, and also to expand the amount of data that are offered. (Supported by the NSF RUI:MCB 1607024). Author contact: wrightnt@jmu.edu.

MOLECULAR DYNAMICS SIMULATIONS OF THE B-GRASP SUPERFAMILY. J. T. Bedford, J. Poutsma, & L. H. Greene, Old Dominion University. Molecular dynamics is a computational field of research where Newton's equations of motion are applied to molecular systems in an *in silico* environment. This technique can be skillfully employed to study protein folding. My research focuses on a group of proteins that share a similar β-grasp topology. Using molecular dynamics allows for the investigation into the role of long-range interactions in determining the structure, folding, and stability of proteins. We propose that a protein's topology is determined, at least in part, by key long-range interactions within the protein. To support this hypothesis two proteins, the immunoglobulin-binding domain of protein G and the small archaeal modifier protein 1, were assessed for persistence of long-range interactions over time. The RMSD was monitored as an indicator of the unfolding process. Simulations with an increased RMSD were found to have fewer long-range interactions and interestingly these interactions were predominately lost between specific secondary elements. Author contact: Lesley Greene, lgreene@odu.edu

PREFERENTIAL PHOSPHATIDYLINOSITOL 5-PHOSPHATE BINDING CONTRIBUTES TO A DESTABILIZATION OF THE VHS DOMAIN STRUCTURE OF TOM1. Wen Xiong[1], Tuo-Xian Tang[1], Evan Littleton[1], Arba Karcini[2], Iulia M. Lazar[2] & Daniel G. S. Capelluto[1], Department of Biological Sciences, Biocomplexity Institute, and Center for Soft Matter and Biological Physics, Virginia Tech, [2]Department of Biological Sciences, Virginia Tech. Target of Myb 1 (Tom1) transports endosomal ubiquitinated proteins that are targeted for degradation in the lysosomal pathway. In a bacterial infection model, Tom1 was observed to promote the synthesis of phosphatidylinositol-5-phosphate (PtdIns5P), which switches Tom1 from its cargo trafficking function to a bacterial survival signaling. Tom1 preferentially binds PtdIns5P *via* its VHS domain, but the effects of PtdIns5P on the domain structure and function are unknown. Thermal denaturation studies demonstrate that the monomeric

Tom1 VHS domain exhibits a three-state transition behavior. Binding of Tom1 VHS to PtdIns5P leads to local conformational changes that reduced thermostability, interhelical contacts, and conformational compaction of Tom1 VHS, suggesting that PtdIns5P destabilizes the protein domain. Isothermal calorimetry data analysis indicates that Tom1 VHS endothermically binds to PtdIns5P through two noncooperative binding sites. These findings provide mechanistic insights about the recognition of PtdIns5P by the VHS domain that may explain how Tom1, when in a different VHS domain conformational state, interacts with downstream effectors under bacterial infection. Author contact: wxiong@vt.edu

DEVELOPING SMALL MOLECULE INHIBITORS FOR CALPAIN DEPENDENT DEGRADATION OF DESMOPLAKIN. Kendahl L. Ott[1], Taylor L. Albertelli[1], Nathan T. Wright[1], Heather Manring[2], Maegen A. Ackermann[2] & Stuart Campbell[3], [1]Department of Chemistry and Biochemistry, James Madison University, [2]Department of Physiology and Cell Biology, Ohio State University, [3]Department of Biomedical Engineering, Yale University. Desmoplakin (DSP) is a large (260 kD) protein found in the desmosome, a subcellular structure that links the cytoskeleton of one myocyte to that of its neighbor. In cardiomyocytes, desmoplakin's main function is to maintain cell-to-cell adhesion and synchronization during heart contractions. A mutation hot-spot, centered around the SH3 domain of DSP, is associated with arrhythmogenic cardiomyopathy, but the underlying mechanism(s) of this association isn't well studied. Through various fluorescence techniques, it can be shown that many of these disease-causing mutations display increased calpain sensitivity. Additionally, structural and computational studies on DSP variants show that this cleavage event is driven not through a gross structural change, but instead through the discrete exposure of a normally-occluded calpain cleavage site. Initial *in silico* and *in vitro* screens of small molecules suggest the feasibility of developing a pharmaceutical solution to prevent calpain-mediated DSP cleavage. (Supported by: NSF REU (CHE-1757874), NSF RUI MCB-1607024, Henry Dreyfus Teacher-Scholar Award & VAS Undergraduate research minigrant). Author Contact: Kendahl L. Ott, ottkl@dukes.jmu.edu

THE FUNCTIONAL BASIS OF PHAFIN2 IN AUTOPHAGY. Tuo-Xian Tang & Daniel G. S. Capelluto, Dept. of Biol., Virginia Tech. Autophagy is a highly conserved cellular pathway in the eukaryotic cells. A portion of the cytosol, which contains invading pathogens and long-lived proteins, is taken up by an autophagosome. This double-membrane organelle fuses with lysosomes, where the contents were digested by the lysosomal enzymes. Previous data showed that Phafin2 was involved in autophagy. After the induction of autophagy, Phafin2 and Akt accumulate on the lysosomal membranes through the interactions between Phafin2 and phosphatidylinositol 3-phosphate (PtdIns(3)P). Phafin2 has two domains, one N-terminal PH (Pleckstrin Homology) domain and one C-terminal FYVE (Fab 1, YOTB, Vac 1, and EEA 1) domain. In this study, the binding affinity between PtdIns(3)P and Phafin2 was studied by surface plasmon resonance. Results showed that Phafin2 binds PtdIns(3)P with high affinity, triggering minor conformational changes in the protein. We also demonstrated that Phafin2 FYVE domain is responsible for the binding of PtdIns(3)P. Another interesting finding is that Phafin2 can cause membrane curvature, which may be required

for tethering of lysosomes to autophagosomes, and consequently initiating autophagy. Author contact: tangtx@vt.edu.

THE STRUCTURE AND FUNCTIONAL CHARACTERIZATION OF LEISHMANIA DONOVANI'S UFM-YLATION PATHWAY. Adrianne D. Lee & Christopher E. Berndsen, Dept. of Chem. and Biochem., James Madison Uni.. Ubiquitin fold modifier 1 (Ufm1) a ubiquitin-like protein and Ubiquitin fold modifier activating enzyme (Uba5, E1) are proteins found in eukaryotic organisms that play a crucial role in cell cycle regulation, signal transduction, and ER stress. Leishmania donovani (Ld) is a trypanosomatid parasite that has been shown to have enzymes homologous to Uba5 and Ufm1. Leishmania Ufm1 and Uba5, as well as the substrate-targeted proteins, are associated with the mitochondria which have not been observed in other organisms. This suggests that these Leishmania proteins may have physiological roles not yet described in other organisms. Leishmania donovani causes leishmaniasis, a disease that is accompanied by sores and lesions that will appear at varying depths of the body depending on the type and increases the host's susceptibility to co-infection with other diseases. There are currently no effective vaccines for leishmaniasis. LdUfm1, an N-terminally truncated form of LdUfm1, and LdUba5. LdUfm1 and LdUfm1(tr.) were successfully purified and were characterized with SEC-MALS. We then performed gel migration shift assays to demonstrate the compatibility of the human and Leishmania systems to conjugate LdUfm1. We found that full-length Leishmania Ufm1 but not the truncated form were viable substrates for human Uba5, suggesting a role for the N-terminus of Ufm1 conjugation. We are currently working to purify LdUba5 further for functional and structural comparisons to the human enzyme. Additionally, we began setting crystal trays to obtain protein crystals for structure determination. We have preliminarily obtained crystals of the truncated Ufm1. Future work will optimize these crystals, perform further experiments for structural characterization and explore the cross-reaction between the human and Leishmania enzymes. Characterization of the Leishmania donovani conjugation pathway could facilitate the development of therapeutic treatments for leishmaniasis. Author contact: Christopher Berndsen, berndsce@jmu.edu

IONIC STRENGTH-INDUCED TETRAMER FORMATION IN THE PAR-4 TUMOR SUPPRESSOR. Andrea M. Clark, Komala Ponniah, Meghan S. Warden, Emily M. Raitt, Benjamin G. Smith & Steven M. Pascal, Department of Chemistry and Biochemistry, Old Dominion University. The prostate apoptosis response-4 (Par-4) tumor suppressor can selectively kill cancer cells via apoptosis while leaving healthy cells unharmed. Full length Par-4 has been shown to be predominantly intrinsically disordered *in vitro* under neutral conditions. As part of the apoptotic process, cellular Par-4 is cleaved at D131 by caspase-3, which generates a 24 kilodalton C-terminal activated fragment (cl-Par-4) that enters the nucleus and inhibits pro-survival genes, thereby preventing cancer cell proliferation. Here, the structure of cl-Par-4 was investigated using circular dichroism (CD) spectroscopy, dynamic light scattering (DLS), intrinsic tyrosine fluorescence, and size exclusion chromatography with multi-angle light scattering (SEC-MALS). Biophysical characterization shows that cl-Par-4 aggregates and is disordered at low ionic strength. However, with increasing ionic strength, cl-Par-4 becomes

progressively more helical and less aggregated, ultimately forming highly helical tetramers at high NaCl concentration. These results, together with previous results showing induced folding at acidic pH, suggest that the *in vivo* structure and self-association state of cl-Par-4 may be strongly dependent upon cellular environment. Author contact: Andrea Clark akorell@odu.edu and Steven Pascal spascal@odu.edu.

Posters

MICROPLASTICS IN FRESHWATER WETLAND SOILS. Camilla Anne Alsobrook[1] & Scott Neubauer[2]. [1]John Tyler Community College and [2]Department of Biology, Virginia Commonwealth University. Microplastics, which are small particles less than 2mm in length and less than 1 mm in diameter, were first found in nature in 2004. Microplastics are dangerous due to their effect on the trophic structure of an ecosystem. Research has shown that microplastics have sorption qualities, which is troubling due to the known toxic effects caused to crustaceans. This is crucial to human health due to the possible of bioamplification of toxins. In the 14 years since the initial discovery of microplastics, it has been an ongoing struggle to find a cost-effective and relatively simple approach to extract microplastics in order to study them to understand their effect on the ecosystems they've come to overwhelm. I believe that if we examine soil samples from different depths and geographic locations, then we will be able to quantify the different types of plastics present. This is important because no one has studied the effect of microplastics on freshwater wetland soils. In my project, I used the Sediment-Microplastic Isolation Unit (SMI). The SMI uses a density separation method where lighter particles (e.g., microplastics) float to the top of the device while the denser particles (e.g., sediments) sink to the bottom. I used this device isolate microplastics from soil samples from three tidal freshwater wetland sites in Virginia. Soils were collected at different depths, ranging from 0-33 cm. Two of the study sites were herbaceous marshes (one each on James and Pamunkey Rivers) whereas the third site was a wetland on the Rappahannock River characterized by shrub-scrub vegetation. In analyzing the microplastics, I will be categorizing them based on location, depth found, appearance (size and color), as well as state of erosion. This data will allow me to build a solid database of microplastics, which I will then be able to use to understand trends in the depths and types of microplastics. In future studies, I will take the quantification data and use it to create a timeline of microplastic introduction to the area and which industries create the most microplastics. I will then use this data to determine which types of microplastics are most harmful to the environment they've been introduced to, with special attention to the trophic structure of the ecosystems they're found in. Studies show that microplastics are harmful to aquatic life, however their impacts on freshwater life are widely unknown given the lack of in-depth research in that area. This experiment should shed light on the life cycle of plastics and their distribution. In further studies, this information will be used when studying the trophic levels of marshes to determine how microplastics have interacted with the native organisms. (Supported by NIH, VCU Bridges to the Baccalaureate R25GM102795). Author contact: sneubauer@vcu.edu

OPTIMIZING A BIOSENSOR-BASED ASSAY FOR UBIQUITINATION ACTIVATION. Roma L. Broadberry & Christopher E. Berndsen, Dept. of Chem. and

Biochem., James Madison Uni. Ubiquitination is a post-translational modification which regulates protein degradation, DNA damage signaling, and inflammatory response. Three transfer enzymes catalyze the reaction's pathway: the E1 activating enzyme, the E2 conjugating enzyme, and the E3 ligating enzyme, respectively. Despite the identification of these enzymes' structure and function, an understanding of their catalytic mechanisms remains incomplete. Due to ubiquitin's extensive involvement in eukaryote biology and protein degradation, clarifying the ubiquitination mechanism holds great potential for anti-cancer therapeutics. E1 uses ATP to adenylate the C-terminus of ubiquitin, forming pyrophosphate and AMP. Most available assays for ubiquitination are either qualitative or use radioactive tracers, thus we wanted to develop a quantitative fluorescent assay to avoid these limitations. The proposed assay relies on a genetically-encoded fluorescent biosensor, known as Perceval, to monitor real-time changes in concentration of ATP during cleavage of ATP to AMP. Developed in the Yellen Lab at Harvard Medical School, Perceval was designed to report sub-second changes in cellular energy as a result of its competitive binding of ATP and ADP. We have worked to adapt the Perceval biosensor toward measuring ATP hydrolysis of E1 in the ubiquitination pathway in vitro. We first started to optimize by examining the fluorescent changes for protein solutions with ATP and AMP. We then tested the sensor at varying concentrations of ATP/AMP. Preliminary data show promising assay abilities for the detection of ATP loss in the presence of different Ubls and E1s, suggesting that the enzymes and protein substrates will not interfere with the sensor. Future directions will work to directly test E1 activity, and then perform assays of the entire cascade. Author contact: Christopher Berndsen, berndsce@jmu.edu

ANTAGONIZING SEROTONIN 2A RECEPTORS INCREASE THE ANALGESIC RESPONSE MEDIATED BY OXYCODONE IN A MOUSE MODEL OF ANTINOCICEPTION. X. K. Cuno Lavilla[1], S. Sierra San Nicolás[2], D. Stevens[3] & J. González-Maeso[2], [1]Thomas Nelson Community College and [2]Dept. of Physiology & Biophysics and [3]Dept. of Pharmacology & Toxicology, Virginia Commonwealth University. Among the vast serotonin receptor family, 5-HT_{2A} receptors are involved in a number of physiological processes including nociception. However, the role of the 5-HT_{2A} receptors in the spinal cord is somewhat controversial. Whereas early studies showed contradicting results upon the intrathecal administration of the $5HT_{2A}$ agonist DOI, probably due to differences in dosage, more recent studies support the pronociceptive role of $5HT_{2A}$ in the spinal cord. The purpose of this study was to identify the presence of 5-HT_{2A} receptors in the tail-flick reflex (TFR) circuit and determine the contribution of 5-HT_{2A} receptors to the analgesic response mediated by oxycodone. In order to dissect the TFR circuit, we extracted and processed the dorsal root ganglion (DRG) and lumbar spinal cord from three C57BL/6 male mice. After three days, we performed an immunohistofluorescence in both of them to detect $5HT_{2A}$ receptors in the soma of bipolar neurons (sensory afferents) and ventral horn neurons (motor efferent). For the behavior experiments, we used 20 adults C57BL/6 male mice and 5 adults $5HT_{2A}$ knock-out mice of 129S6/Sv background. Mice were pretreated with i.p injections of volinanserin (antagonist of $5HT_{2A}$ receptors) at a dose of 1, 5 and 10 mg/kg and then cumulative doses of oxycodone (mu opioid receptor agonist) p.o. 1, 2, 4, 8, 16, 32, 64 mg/kg. The measurement of acute thermal nociceptive activity was performed by

the hot thermal immersion test. We identified the presence of 5-HT_{2A}receptors in the DRGs and ventral horn neurons of the spinal cord. Behavior experiments showed that animals pretreated with high doses of volinanserin (5 and 10 mg/kg) showed increased analgesic potency in WT mice treated with oxycodone. Similarly, the administration of oxycodone to KO mice induced a significant increased analgesic response compared to WT mice. Together, these results suggest that the combination of oxycodone with a selective 5-HT_{2A} receptor antagonist could represent a therapeutic strategy to reduce pain state. (Supported by NIH, VCU Bridges to the Baccalaureate R25GM102795). Author contact: javier.maeso@vcuhealth.org

AUTOINHIBITION MECHANISM OF THE ENDOSOMAL TRAFFICKING PROTEIN TOM1. Evan Littleton [1], Wen Xiong [1], Anne Brown [2], and Daniel G. S. Capelluto [1], [1] Department of Biological Sciences and [2] University Libraries Department, Virginia Polytechnic Institute and State University. In eukaryotes, Tom1 is a protein involved in trafficking of proteins (cargo) through the early endosomes for their degradation. During bacterial infection, Tom1 is recruited to signaling endosomes, rather than early endosomes, leading to a delay of the protein degradation pathway. This occurs because bacteria induce production of phosphatidylinositol 5-phosphate [PI(5)P] in the host cell, increasing the intracellular levels of PI(5)P. It is proposed that, in order to keep the host cell alive, bacteria cause this increase in PI(5)P to prevent the degradation of Tom1-mediate host proteins required for bacterial survival. Tom1 possesses a N-terminal VHS domain that can bind to ubiquitin on ubiquitinated proteins, but this may be altered by high levels of PI(5)P. Despite the ability of the VHS domain to bind to PI(5)P, the full length Tom1 protein has not been shown to bind to PI(5)P. It is hypothesized that this self-regulation may be due to a short DXXLL motif located near the VHS domain in Tom1 that can compete with PI(5)P for VHS binding. To test this, mutagenesis of the DXXLL motif was performed to generate Tom1 mutants. These protein mutants were tested for their ability to bind to PI(5)P and compared to wild type Tom1. Mutagenesis of this region led to recovery of Tom1 binding to PI(5)P and shows similar binding as PI(5)P to VHS binding. This unveils a crucial role for the DXXLL motif in regulating binding of Tom1 to PI(5)P, and subsequently regulating the effects of bacterial infection on the endosomal protein trafficking pathway. Author contact: Evan Littleton evanlitt@vt.edu.

CHARACTERIZATION OF THE UFM-YLATION ACTIVATION MECHANISM BY UBA5. Benjamin Ruszala & Christopher E. Berndsen, Dept. of Chem. and Biochem., James Madison Univ. Post translational modification designate proteins for re-localization, changes in function/activity, and degradation. Ubiquitination is a type of post translational modification carried out by three classes of enzymes: E1 activating enzymes, E2 conjugating enzyme, and E3 ligating enzymes. E1 enzymes regulate the initial step of the pathway and fall into two classes: canonical and non-canonical. Uba5 is a non-canonical E1 enzyme which activates the ubiquitin like molecule, Ufm1. Uba5 activates Ufm1 through adenylation of the C-terminus of the molecule which is followed by a thioesterification step. This latter reaction forms a covalent bond between Uba5 and Ufm1. The details of this mechanism are not clearly understood. This project modeled the structure of Uba5 through the dimerization step, ATP binding, Ufm1 binding, and the

adenylation reaction to predict changes in dynamics and amino acid pKA. Molecular dynamics simulations were ran for using the AMBER14 force field and the data analyzed in R. Out simulations suggest that Uba5 becomes less dynamic as the mechanism progresses. Moreover, we have identified a number of interesting weak interactions which may play a role in substrate binding. These models will be empirically tested and refined based on the results of biochemical studies. Author contact: Christopher Berndsen, berndsce@jmu.edu

INTERACTIONS BETWEEN AN ANTI-CANCER DRUG AND THE PAR-4 TUMOR SUPPRESSOR. Laura E. Sweet, Andrea M. Clark, Komala Ponniah & Steven M. Pascal. Department of Chemistry and Biochemistry Old Dominion University. Par-4 is an intrinsically disordered protein that acts to inhibit pro-survival pathways in cancer cells. The activated fragment, cl-Par-4, is produced upon cleavage by caspase-3. Due to its disorder, the structure of Par-4 is difficult to determine via standard protein characterization techniques. We have used extreme conditions to induce folding; however, these conditions are far from physiological and therefore may not apply to the therapeutic approach of cancer treatment. The disorder seen is likely caused by electrostatic repulsions of amino acid residues in the coiled coil domain that destabilize the structure. To help overcome this repulsion, we have employed an anti-cancer drug as a cross-linking agent. Circular dichroism experiments of cl-Par-4 show partial disorder in physiological conditions, but upon the addition of the drug, cl-Par-4 becomes helical and folded. We expect that this stabilized structure will be more effective at killing cancer cells. Author contacts: lswee001@odu.edu, spascal@odu.edu.

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Rates of Relative Sea Level Rise Along the United States East Coast

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ABSTRACT

Recent studies have indicated that some coastal areas, including the East Coast of the United States, are experiencing higher rates of sea level rise than the global average. Rates of relative sea level rise are affected by changes in ocean dynamics, as well as by surface elevation fluctuations due to local land subsidence or uplift. In this study, we derived long-term trends in annual mean relative sea level using tide gauge data obtained from the Permanent Service for Mean Sea Level for stations along the United States East Coast. Stations were grouped by location into the Northeast, Mid-Atlantic, and Southeast regions of the United States East Coast, with the intent of investigating relative sea level rise variability between the three regions. Trends for each region were calculated using stations with a minimum record length of at least 30 years; the longest record began in 1856. Records that were less than 70 percent complete were rejected. For the three-year moving averages, Northeast trends were calculated to be 2.79 mm/yr, Mid-Atlantic trends were calculated to be 4.02 mm/yr, and Southeast trends were calculated to be 2.92 mm/yr. For the five-year moving averages, Northeast trends were calculated to be 2.81 mm/yr, Mid-Atlantic trends were calculated to be 4.04 mm/yr, and Southeast trends were calculated to be 2.91 mm/yr. The Mid-Atlantic region of the United States East Coast was determined to be experiencing significantly higher rates of relative sea level rise than the other regions.

Keywords: Rates of relative sea level rise, United States East Coast, Mid-Atlantic, Relative sea level rise variability

INTRODUCTION

The consequences of climate change vary for different geographic locations around the world, but for the U.S. East Coast, climate change induced factors are forcing the issue of rising sea levels to take center stage (Davis and Vinogradova, 2017). From 1993 to 2010, global sea levels rose at a rate of 3.2 millimeters per year (mm/yr); however, rates of sea level rise (SLR) vary spatially across the globe due to geologic and oceanographic factors making rates of local, or relative sea level rise (RSLR), more extreme in certain areas compared to others (Wong et al., 2014). RSLR is the resulting combination of global (eustatic) sea level rise, geologic factors such as glacial isostatic

adjustment (GIA), land subsidence due to extensive groundwater pumping, increased coastal erosion, and various sea factors including thermal expansion, melting glaciers and ice sheets, and slowing ocean currents (North Carolina Coastal Resources Commission Science Panel, 2015). Different rates of RSLR and its drivers impact coastal communities through the accelerated erosion of shorelines, increases in the magnitude and frequency of flooding, and the alteration of wetland and coastal ecosystems (Eggleston and Pope, 2013). Low-lying cities such as Norfolk, Virginia have already experienced escalations in flooding related to RSLR (Ezer, 2018).

The U.S. East Coast has become an area of interest for SLR due to the variability in rates between locations (Davis and Vinogradova, 2017). Studies have found accelerated rates of SLR north of Cape Hatteras along the east coast (Ezer and Atkinson, 2014), which corresponds with an offshore shift and weakening of the Gulf Stream (Ezer et al. 2013). Accelerated SLR was also highly correlated with accelerations in minor flooding. While the U.S. East Coast was found to be a "hotspot of accelerated flooding," the Mid-Atlantic coastal area north of Cape Hatteras, specifically, has experienced substantial increases in flooding (Ezer and Atkinson, 2014). However, it was not until 2009 that the first observational study was performed that identified differences in rates of SLR along the U.S. East Coast (Engelhart et al., 2009). Engelhart et al. (2009) found increasing RSLR from Maine to South Carolina, with a maximum in the Mid-Atlantic. After removing the GIA signal from the tide-gauge data, a significant amount of spatial variability in SLR was identified for the 20th century, indicating ocean steric effects and/or the melting of the Greenland Ice Sheet may be responsible rather than vertical land motion. Highlighting which regions of the East Coast are most vulnerable to rising sea levels provides policymakers the opportunity to plan for SLR related hazards. Rather than attribute significantly different rates of RSLR in a region to any specific factors, the goal of this study is to simply determine if there are any statistically meaningful differences in rates of RSLR between three tidal-gauge data groups along the U.S. East Coast. For this comparative analysis, we sub-divided the available U.S. East Coast tidal-gauge data set into three contiguous geographic regions and compared observed rates of RSLR for each region.

MATERIALS AND METHODS

Annual tide gauge data recorded in millimeters (mm) was downloaded from the Permanent Service for Mean Sea Levels (Holgate et al., 2013; PSMSL, 2018). Located in Liverpool at the National Oceanography Centre, PSMSL maintains, publishes, analyzes, and interprets sea level data from a global network of tide gauges. PSMSL exercises quality control with established requirements that contributing organizations adhere to while submitting data. Furthermore, PSMSL provides instructions for the treatment of incomplete tidal records and the calculation of monthly and annual mean sea levels. For quality control in this study, data was downloaded from a tide gauge station only if two conditions were satisfied: the time series extended for at least 30 years and the data set was at least 70 percent complete. Overall, 37 stations from Maine to Florida satisfied these conditions.

Three and five-year moving averages for the annual RSLR data were calculated for each station. We created time series graphs for each moving average and generated linear trendlines for each graph. The slope of each linear trendline was interpreted to be the rate of RSLR for each station in mm/yr.

We sub-divided the U.S. East Coast tidal-gauge data set into three contiguous geographic regions to evaluate and compare rates of RSLR for each region: the Northeast, the Mid-Atlantic (approximately between latitudes of 40° 28' 0" N and 36° 49' 18" N), and the Southeast (Figure 1). The latitudes chosen in the study were estimated and based on a definition created by the United States Geological Survey (Greene et al., 2005). The Northeast region was designated to be all coastal states north of the Mid-Atlantic region along the U.S. East Coast; the Southeast region was determined to be all coastal states south of the Mid-Atlantic region along the U.S. East Coast. The Northeast and Mid-Atlantic regions each contained tidal gauge data from 14 stations, the Southeast region contained tidal gauge data from nine stations. The data did not satisfy the normality assumption, therefore a nonparametric Kruskal-Wallis H Test was conducted to compare rates of RSLR for both the three- and five-year moving averages from each region to determine if there were any significant statistical differences in rates of RSLR between the three regions along the U.S. East Coast. A pairwise post-hoc test was also performed to establish which region had significantly different rates of RSLR.

RESULTS

Interpreted rates of RSLR for the three-year moving average were calculated to be 2.79 mm/yr in the Northeast, 4.02 mm/yr in the Mid-Atlantic, and 2.92 mm/yr in the Southeast. Trends of RSLR for the five-year moving average were calculated to be 2.81 mm/yr in the Northeast, 4.04 mm/yr in the Mid-Atlantic, and 2.91 mm/yr in the Southeast. Stations located in the Mid-Atlantic region generally showed visibly higher rates of RSLR than for stations in both the North and Southeast regions (Figures 2 - 4). Additionally, the most Southerly station in the Northeast region and most Northerly station in the Southeast region also showed visibly higher rates of RSLR than for other stations in their respective regions. Furthermore, all stations in each region displayed distinct trends of increasing rates of RSLR throughout each record. Within each region, trends of RSLR calculated for the three and five-year moving averages were similar.

The calculated variance for the three-year moving averages of interpreted trends of RSLR rates was lowest for stations in the Mid-Atlantic region (0.53), and highest among stations in the Southeast region (0.83). For the five-year moving averages, the calculated variance of interpreted trends of RSLR rates was lowest for stations in the Mid-Atlantic region (0.57), and highest among stations in the Southeast region (0.95). At an alpha level of 0.05, the Mid-Atlantic region showed significantly higher rates of RSLR than the Northeast region for both the three-year moving averages ($P = 0.001$) and five-year moving averages ($P = 0.001$). While calculated rates of RSLR were closer between the Mid-Atlantic and Southeast regions, the Mid-Atlantic region showed significantly higher rates of RSLR for both the three-year moving averages ($P = 0.01$) and five-year moving averages ($P = 0.01$). Rates of RSLR were not significantly different between the Northeast and Southeast stations for either the three-year moving averages ($P = 1$) or the

five-year moving averages (P = 1). For the three and five-year moving averages, the Northeast region had an outlier (Bergen Point, NJ) the Mid-Atlantic region had an outlier (Chesapeake Bay Bridge Tunnel, VA) and the Southeast region had an outlier (Duck Pier, NC) (Figures 5 and 6).

DISCUSSION

The results of this study have determined that the Mid-Atlantic region of the U.S. East Coast is experiencing significantly higher rates of RSLR compared to the Northeast and Southeast regions (Tables 1 and 2). This study was a preliminary examination of a dataset and purely a statistical analysis that did not attempt to determine which factors are responsible for this significant difference in rates of RSLR. Our results are in agreement with previous work that examines SLR and RSLR along the U. S. East Coast. The SLR acceleration found by Ezer and Atkinson (2014) likely has influenced this statistically significant difference found in rates of RSLR between the Mid-Atlantic region and other regions along the U. S. East Coast. Due to the variety of factors affecting eustatic SLR and vertical land motion, it is plausible that a combination of factors that play smaller roles in rates of RSLR for the Northeast and Southeast regions of the U. S. East Coast, are more prominent in the Mid-Atlantic region and have resulted in increased rates of RSLR. Although significant portions of the Atlantic Coast are experiencing land subsidence due to GIA, other processes have led to spatial and temporal variability in crustal movement within the Atlantic coastal plain (Karegar et al., 2016). Portions of the Mid-Atlantic region, including the southern Chesapeake Bay region, are experiencing substantial rates of land subsidence related to aquifer compaction caused by extensive groundwater withdrawal, as well as subsidence due to GIA from the past melting of the Laurentide Ice sheet (Eggleston and Pope, 2013). There is also evidence that a weakening of the Atlantic Meridional Overturning Circulation caused by a diminished temperature gradient between the Arctic and equator has resulted in a slowdown of the Gulf Stream, leading to a pile-up of water along the Mid-Atlantic region further increasing RSLR (Ezer et al., 2013).

Our division of the U.S. East Coast was not optimized to look at any specific cause of observed differences in RSLR, as our averaging over large areas might be averaging in hotspots and local causes of increased RSLR. Ezer et al. (2013) suggested that ocean dynamics including changes in ocean circulation may have significant effects in coastal sea level changes, which also corresponds with increased RSLR rates in the Mid-Atlantic region due to its proximity to the Gulf Stream. As indicated by Ezer et al. (2013) and Englehart et al. (2009), spatial variations in ocean dynamics play significant roles in SLR and RSLR variability. Future work could involve different regional groupings based on geographic distributions of climate change signals, to establish what factors of RSLR are impacting different regions. The identification of significant differences in rates of RSLR and flooding can enable local and state government officials with the information necessary to appropriately modify their infrastructure to withstand potential flood events. Further research will be required to isolate which factors have the largest impact on RSLR, allowing policymakers to properly develop plans to mitigate the effects of rising sea levels on coastal areas.

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Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 361-409.

Table 1. Kruskal-Wallis H Test between the three regions of U.S East Coast with a pairwise post-hoc test to determine which regions were significantly different for 3 year moving average RSLR rates.

Sample 1 RSLR Rates Vs. Sample 2 RSLR Rates	Test Statistic	Standard Error	Standard Test Statistic	Significance	Adjusted Significance
Northeast 3-Year Moving Averages Vs. Southeast 3-Year Moving Averages	-1.88	4.63	-0.41	0.68	1
Northeast 3-Year Moving Averages Vs. Mid-Atlantic 3-Year Moving Averages	-15.21	4.09	-3.72	0	0.001
Southeast 3-Year Moving Averages Vs. Mid-Atlantic 3-Year Moving Averages	13.33	4.63	2.88	0.004	0.01

Table 2. Kruskal-Wallis H Test between the three regions of U.S East Coast with a pairwise post-hoc test to determine which regions were significantly different for 5 year moving average RSLR rates.

Sample 1 RSLR Rates Vs. Sample 2 RSLR Rates	Test Statistic	Standard Error	Standard Test Statistic	Significance	Adjusted Significance
Northeast 5-Year Moving Averages Vs. Southeast 5-Year Moving Averages	-1.81	4.63	-0.39	0.7	1
Northeast 5-Year Moving Averages Vs. Mid-Atlantic 5-Year Moving Averages	-15.07	4.09	-3.68	0	0.001
Southeast 5-Year Moving Averages Vs. Mid-Atlantic 5-Year Moving Averages	13.26	4.63	2.87	0.004	0.01

Figure 1. Map of U.S. East Coast showing the locations of tide gauge stations comprising each region. Blue markers represent Northeast stations, green represents Mid-Atlantic stations, and blue represent Southeast Stations.

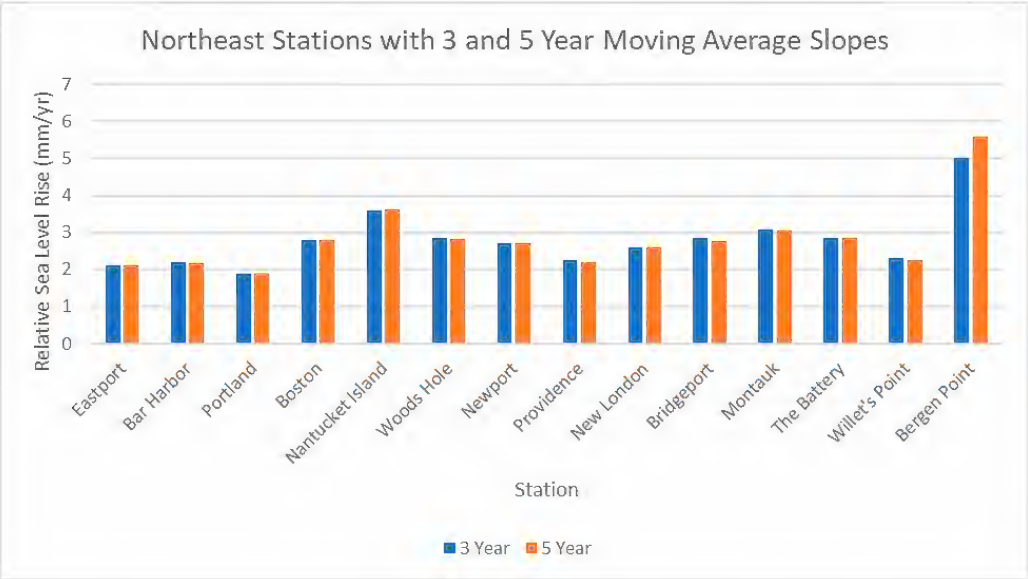

Figure 2. U.S. East Coast Northeast tide gauge station locations and their interpreted RSLR rates.

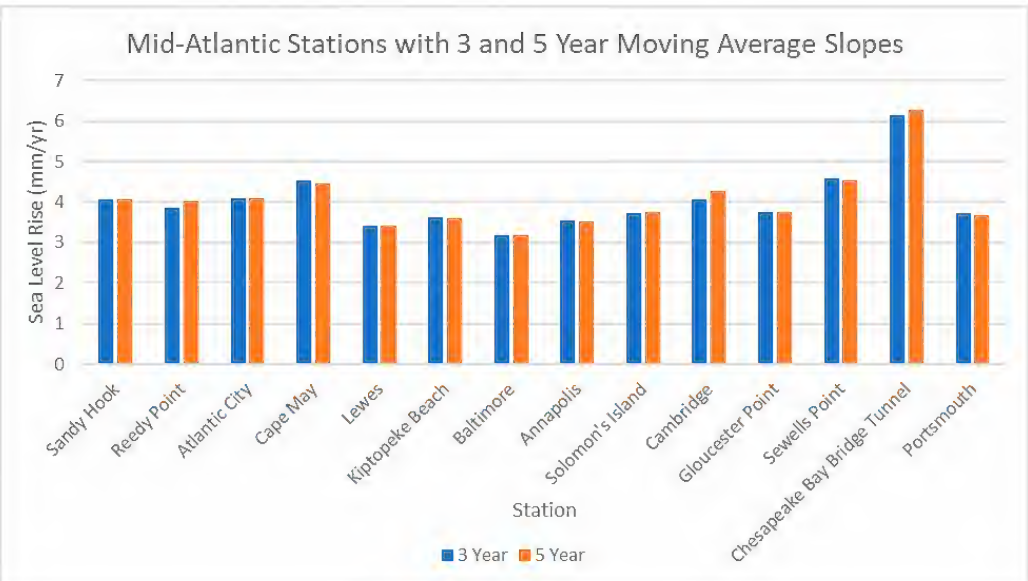

Figure 3. U.S. East Coast Mid-Atlantic tide gauge station locations and their interpreted RSLR rates.

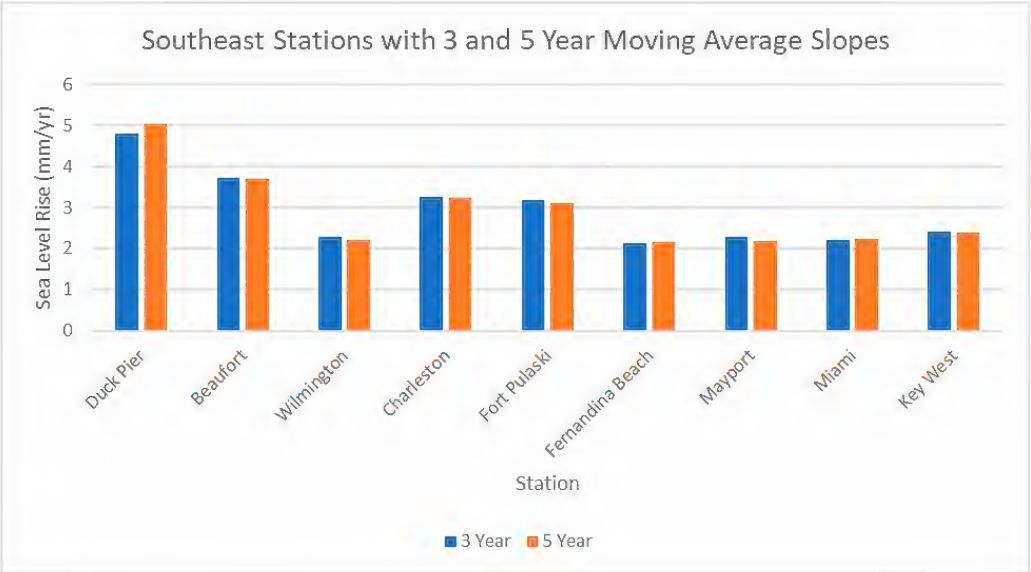

Figure 4. U.S. East Coast Southeast tide gauge station locations and their interpreted RSLR rates.

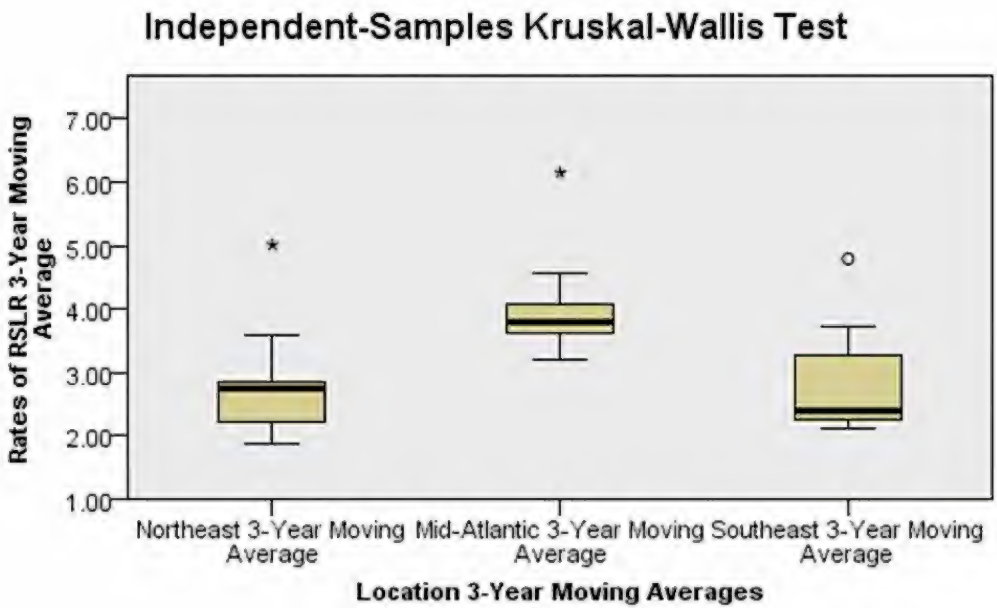

Figure 5. Box and whisker plot showing distributions of 3-year moving average rates of RSLR for each region of U.S East Coast.

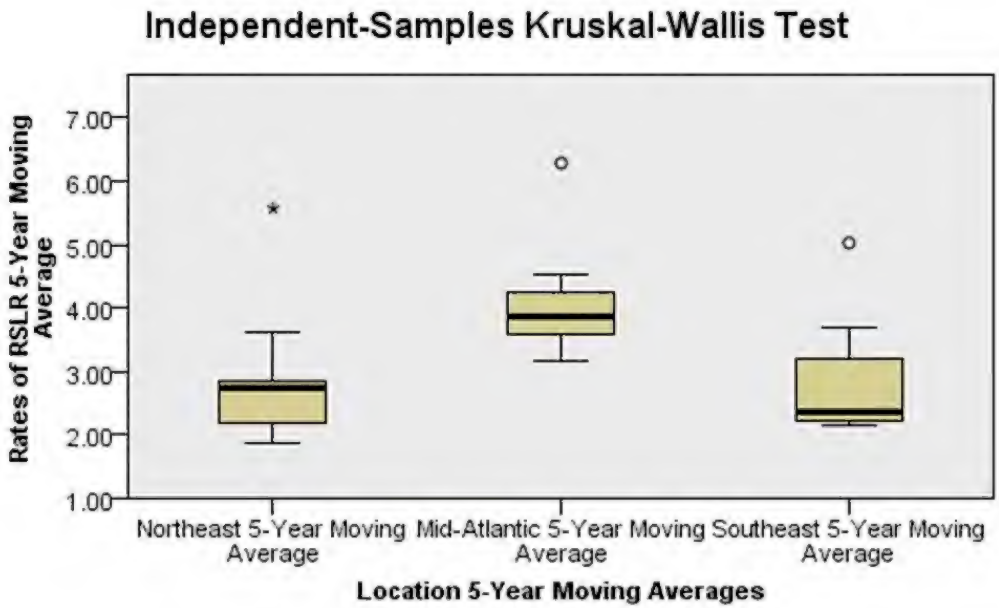

Figure 6. Box and whisker plot showing distributions of 5-year moving average rates of RSLR for each region of U.S East Coast.

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Detecting Change: Observations of Temperature and Precipitation Across Virginia's Climate Divisions

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ABSTRACT

Modern global climate change is primarily attributable to human activities and the release of greenhouse gases into the atmosphere. Climate change impacts span a range of sectors, including agriculture, forestry, public health, and water resource management. The Commonwealth of Virginia has already and will continue to deal with many of these impacts, yet lacks concentrated effort to detect, document, and adapt to local climate changes. This study documents observed changes in temperature and precipitation across Virginia's six climate divisions. Mean seasonal anomalies of minimum temperature, maximum temperature, and precipitation from 1986 to 2016 are examined relative to a long-term 1895-2000 baseline. Additionally, the study assesses and reports full-record (1895-2016) trends for each climate division. Results demonstrate warming across all climate divisions in Virginia, particularly during the winter season (December, January, and February). Precipitation changes vary across the Commonwealth and seasons. Drying conditions, particularly in the Eastern and Western Piedmont, are noteworthy during the summer, while wetter conditions prevail in the spring and autumn. Former Governor Kaine's 2008 Climate Action Plan and subsequent 2016 update by Governor McAuliffe's administration called for a Virginia climate information clearinghouse where the public and decision-makers could efficiently access valuable weather and climate information. This paper represents a first step in this yet unrealized plan.

INTRODUCTION

Observed warming of the climate system since the mid-20th century is indisputable and has been shown to be driven dominantly by human activities, primarily the emission of greenhouse gases from the combustion of fossil fuels (IPCC, 2014; USGCRP, 2018). Numerous observable impacts relevant to human experience are already underway, including those related to public health (Watts et al., 2018), reductions

in crop yields (Zhao et al., 2017), diminished benefits to humans from natural ecosystems (Nelson et al., 2013), sea level rise (Boon et al., 2018), global changes in plant and animal phenology (Buitenwerf et al., 2015), and increased risk of heat waves (Mora et al., 2017). Many of these impacts are generally expected to worsen and/or intensify into the future under emissions scenarios with large anthropogenic inputs of heat-trapping gases like carbon dioxide and methane (USGCRP, 2018).

Much of the climate change and resilience conversation in Virginia, however, has generally relied on data such as central estimates of end-of-century (~2100) conditions as simulated in global climate models (e.g., Virginia Climate Fever by Steve Nash and former Governor Tim Kaine's Climate Action Plan) or observational datasets averaged over the entire Southeastern climate region (e.g. USGCRP, 2017) instead of focusing on present-day and historical information from within the Commonwealth. While this is not necessarily problematic in and of itself, a baseline estimate of the amount of climate change that has already happened in our state could set metrics for better communication of the climate impacts that are occurring in the Commonwealth, such as public health burdens, invasive and pest species expansions, and agricultural yields trends. Furthermore, these datasets may lack the location-specific details needed to develop effective and efficient climate resilience policy at the city or county level. While dynamically downscaled, regional climate models can improve our understanding of possible future climate change scenarios, decision makers require place-based information to design interventions to cope with the consequences of global warming (e.g., Portland, Oregon's *Climate Change Preparation Strategy*, available at: https://www.portlandoregon.gov/bps/article/503193). Ultimately, aggregation of climate observations onto a global or even regional scale hinders progress toward the goals set forth by the Governor's Commission on Climate Change in the 2008 Climate Action Plan for the Commonwealth (available at: http://www.sealevelrisevirginia.net/docs/homepage/CCC_Final_Report-Final_12152008.pdf) that stated:

a. *Inventory the amount of and contributors to Virginia's greenhouse gas emissions, and projections through 2025.*
b. *Evaluate expected impacts of climate change on Virginia's natural resources, the health of its citizens, and the economy, including the industries of agriculture, forestry, tourism, and insurance.*
c. *Identify what Virginia needs to do to prepare for the likely consequences of climate change.*
d. *Identify the actions (beyond those identified in the Energy Plan) that need to be taken to achieve the 30% reduction goal.*
e. *Identify climate change approaches being pursued by other states, regions, and the federal government.*

In 2016, the McAuliffe administration issued an update to this original Climate Action Plan with the recommendation that a Virginia climate information clearinghouse be established. This paper represents a foundational step in that process, which to date has yet to be realized (as well as several of the other stated goals).

Limited work has been done to detect large-scale changes in Virginia's climate, restricting municipalities' ability to investigate hazards as they exist at present. Additionally, up-to-date, Virginia specific weather- and climate-related data and interpretations are not easily available to public or policymaker audiences without investing time and resources into understanding how to access, download, and analyze data gathered from the National Centers for Environmental Information (NCEI).

Using Virginia's 6 climate divisions as scales of analysis, this paper evaluates observed changes across maximum (Tmax) and minimum (Tmin) temperatures as well as precipitation (Prcp). The authors then also address some of the climate change impacts specific to the Commonwealth of Virginia and suggest areas for further work.

DATA AND METHODS

Climate divisional data for the Commonwealth of Virginia were obtained through the NCEI Climate at a Glance database portal. Across the continental United States, there are 344 divisions that aggregate station temperature and precipitation data. Divisional values are weighed and computed by area (Karl and Koss, 1984). Aggregation at this scale is primarily intended for agricultural and hydrologic applications.

We analyze average meteorological seasonal (winter, December-February, "DJF"; spring, March-May, "MAM"; summer, June-August, "JJA"; fall, September-November, "SON") anomalies for 1986-2016 (the most recent climatology) relative to a long-term baseline (1895-2000) for minimum temperature (Tmin), maximum temperature (Tmax), and precipitation (Prcp) for each climate division in Virginia. This baseline and period of analysis were chosen to detect and contextualize recent change in temperature and precipitation in relation to the entire 20th century. We also analyze the entire period of record (1895-2016) of each climate variable in each division for statistically significant long-term trends using ordinary least squares regressions (Appendix). Other studies have utilized station-level data to assess how precipitation has changed across the Commonwealth across the 20th century and present (Smirnov et al., 2018; Allen and Allen, under review).

RESULTS

Temperature

Results indicate positive Tmax anomalies across the Commonwealth, irrespective of season or division (Figure 2; Appendix A). The largest anomalies were observed during the winter season with a statewide mean value of +1.42°F. Additionally, five climate divisions showed a significant long-term positive (warming) trend during the winter. After winter, the largest shifts occurred in springtime (statewide anomaly +0.87°F). Across all seasons, Climate Division 4 (Northern) experienced the largest anomalies over the time period.

Tmin anomalies showed a similar pattern when compared to Tmax (Figure 3; Appendix B). Across all seasons, climate divisions indicate positive Tmin anomalies relative to the long-term average. Winter anomalies are again the largest (+1.46°F) when

compared to other seasons, and Climate Division 4 (Northern) showed the largest anomalies. Three divisions (Tidewater, Eastern Piedmont, Northern) experienced significant long-term shifts across all seasons with respect to Tmin. After winter, the largest Tmin anomalies were observed for the summer season. This differs from the Tmax results.

Precipitation

Across all climate divisions, negative precipitation anomalies were found for the summer season (Figure 4; Appendix C). The Piedmont divisions showed the largest changes. Unlike summer, positive anomalies were found during the spring and autumn seasons. The largest changes were found during the autumn season with the mean statewide 1986-2016 anomaly exceeding +0.4" relative to 1895-2000. In addition to being the largest, autumn anomalies were the only significant long-term trends detected. Tidewater experienced a +0.59" change across the autumn season. Wintertime precipitation varied the most with only minor differences across the divisions. Spatio-temporal variability in precipitation is also noteworthy as the observed changes in Western Piedmont were the largest for the summer (-0.16), but the region showed one of the smallest changes in the winter. Changes to precipitation not captured by this analysis (e.g., sub-daily extremes) are relevant as wintertime precipitation may play a role in flood-related impacts during springtime melt season and tropical systems can deliver significant percentages of our total annual rainfall in a matter of hours.

DISCUSSION AND RECOMMENDATIONS

In all seasons and across all climate divisions, positive temperature anomalies were observed for both Tmax and Tmin, characteristic of an already warming climate in the Commonwealth. However, as expected, regional variations exist. On average, southwestern regions showed a smaller change than the other divisions. The winter season and Climate Division 4 (Northern) showed the largest shifts relative to the long-term average. Some of the long-term warming signal in minimum temperatures (especially in Climate Division 4) is likely linked to increased urbanization during the analysis period. At present, it is beyond the scope of this manuscript to deduce how much of the detected signal is attributable to urbanization and/or greenhouse gas-driven warming, though this is a considerable area of interest as Virginia's urban areas continue to grow into the midcentury (Nowack and Greenfield, 2018). Unlike temperature, precipitation anomalies showed more seasonal variability. Significant, positive trends were observed for the autumn season, but non-significant decreases were found for the summer season (Appendix C). Recent storminess and slowing tropical systems over the last several decades (Kossin, 2018) may be a contributing factor to the autumn results.

While spatio-temporal variability exists and sub-seasonal trends are not analyzed in the present study, our findings ultimately support several other studies that show trends in aggregated weather variables associated with a global climate change. Since the Industrial Revolution and more dramatically over the last 60 years, the Earth has warmed (IPCC, 2014). Since 1901, the planet has warmed 1.3 - 1.6°F per century but this rate has nearly doubled since 1975 (Blunden et al., 2018). Recent assessments have stated that

over the last century, *there is no convincing evidence that natural variability can account for the amount and pattern of global warming observed* (USGCRP, 2017).

Climate change poses a significant medical danger for populations in the US as well as around the world (Watts et al., 2018), and the Department of Defense highlights the impacts of climate change as a *threat multiplier* for military assets (DOD, 2014). A wide-range of ecological and human impacts stem from such environmental change (Rudd et al., 2018). A warmer atmosphere can hold more water vapor, increasing evaporation rates and modifying the hydrologic cycle toward flashier and less consistent rainfall patterns (Kundzewicz et al., 2008). Such changes are relevant to farmers in Virginia who utilize groundwater resources for irrigation or experience increased runoff and soil erosion associated with heavy rain events. Changes in precipitation intensity, duration, and seasonal timing plays an important role in groundwater recharge (e.g. Meixner et al., 2016), transportation (Suarez et al. 2005), school closures, and longer-term implications such as vector habitat or mold and respiratory issues (Chew et al., 2006; Fisk et al., 2007; Institute of Medicine, 2011; Rochlin et al., 2013). According to the Fourth National Climate Assessment (USGCRP, 2018), metropolitan areas, like Norfolk and Virginia Beach, are vulnerable to more frequent flooding and sea level rise, impacting communities, economies, and our national security. As temperatures warm, Appalachian forest communities will experience complex interactions between drought, disease, and wildfire (USGCRP, 2018). In a warmer world, heat-related health issues, which already account for more deaths than any other weather disaster category on average (National Weather Service, 2017), may increase. Longer-lasting, earlier-occurring, and more frequent heat waves play a major role in adverse health outcomes (Sheridan and Allen, 2015). The recent IPCC Special Report on Global Warming of 1.5°C highlights the urgency required to address climate-related impacts (IPCC, 2018). The rapid (e.g., by 2030) decarbonization of nearly all aspects of our society is required to avoid "severe, widespread, and irreversible impacts," as well as concentrated efforts to build climate resilience to the changes already underway and expected in the Commonwealth. Future work on climate-related stressors in Virginia should further our understanding of the effect of urbanization on short-term extreme weather events such as heat waves, interactions between climate and health-related outcomes at least the ZIP Code level, and modeling "what if" scenarios for guided redevelopment of our cities and possible mitigation strategies that achieve the greatest amount of energy efficiency, equitable public health outcomes, and reduction of climate vulnerability in the future of a hotter and wetter Virginia.

The present study is a foundational step toward better informing stakeholders as to the recent changes in our climate system across the Commonwealth of Virginia. Decision-makers must rely on updated, easily-understandable weather and climate-related information.

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Figure 1. Virginia Climate Divisions.

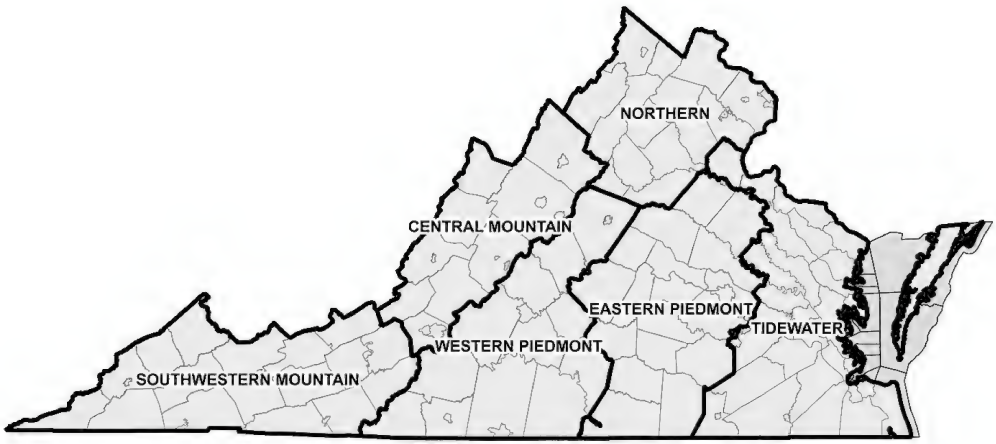


Figure 2. Seasonal maximum temperature anomalies.

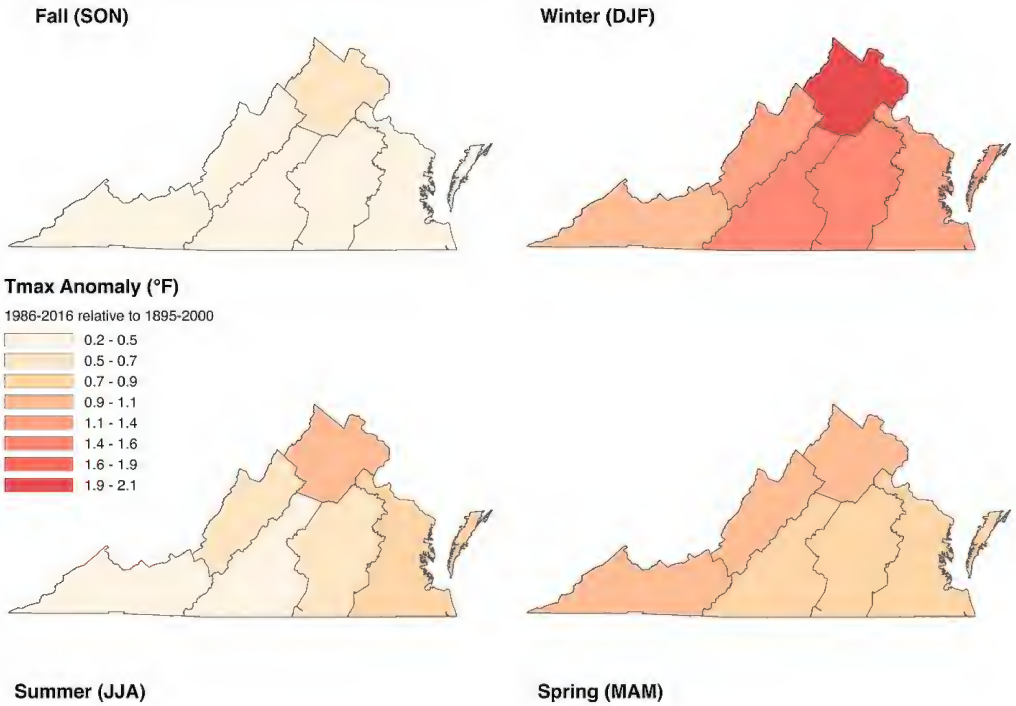


Figure 3. Seasonal minimum temperature anomalies.

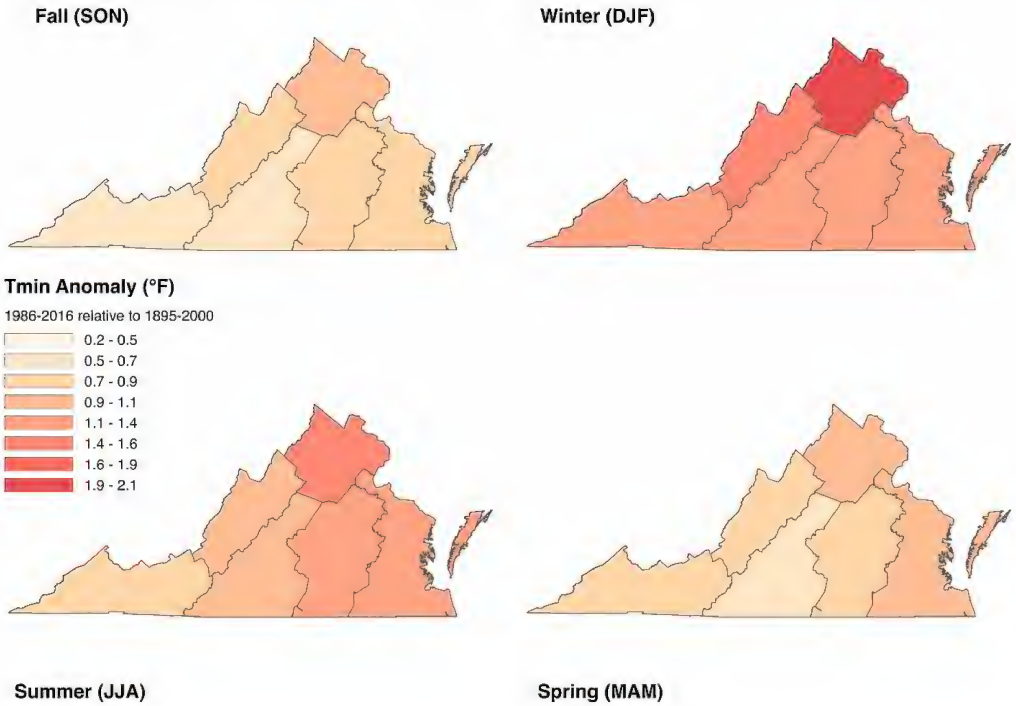
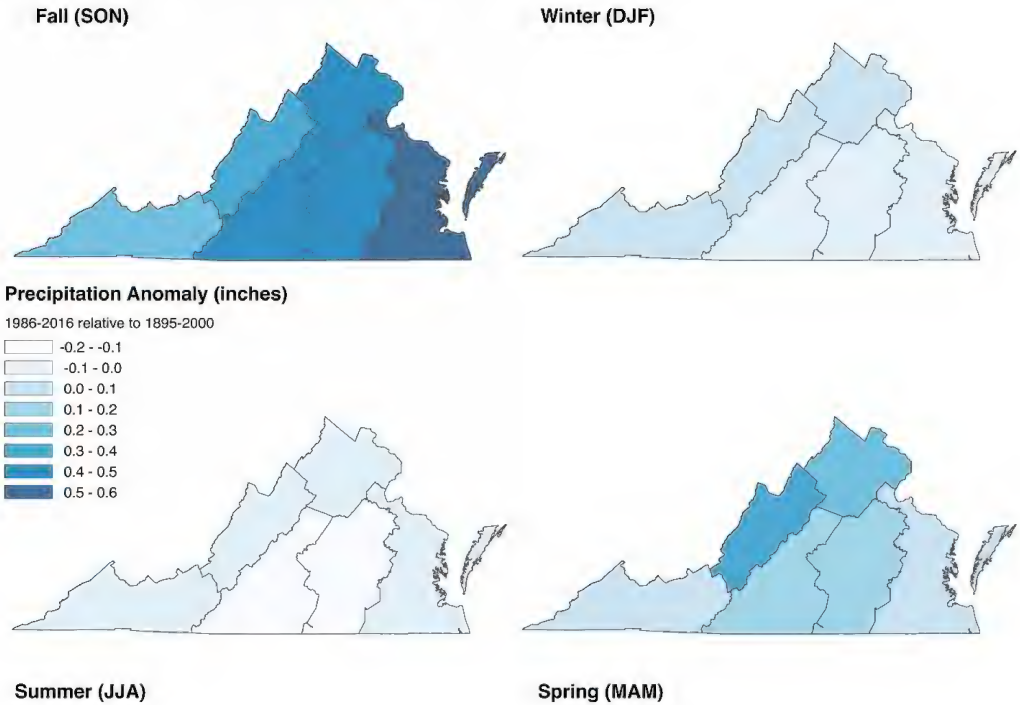


Figure 4. Seasonal precipitation anomalies.



Appendix A. Seasonal Tmax anomalies. Bold italics indicate significant long-term trends (1895-2016) as assessed by ordinary least squares analysis.

Seasonal Tmax (°F) Anomaly (1986-2016 relative to 1895-2000)					
VA Climate Division	Autumn (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Annual
1 - Tidewater	0.44	***1.40***	0.73	0.77	0.83
2 - Eastern Piedmont	0.32	***1.44***	0.69	0.52	0.74
3 - Western Piedmont	0.23	***1.51***	***0.83***	0.40	0.74
4 - Northern	0.60	***1.91***	***1.05***	***0.92***	1.12
5 - Central Mountain	0.30	***1.23***	***0.93***	0.61	0.77
6 - Southwestern Mountain	0.26	1.06	***0.99***	0.36	0.67
Virginia	0.36	1.42	0.87	0.59	0.81

Appendix B. Seasonal Tmin anomalies. Bold italics indicate significant long-term trends (1895-2016) as assessed by ordinary least squares analysis.

Seasonal Tmin (°F) Anomaly (1986-2016 relative to 1895-2000)					
VA Climate Division	Autumn (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Annual
1 - Tidewater	***0.84***	***1.39***	***0.99***	***1.18***	1.10
2 - Eastern Piedmont	***0.85***	***1.38***	***0.84***	***1.24***	1.08
3 - Western Piedmont	0.60	***1.32***	0.65	1.12	0.92
4 - Northern	***1.05***	***2.05***	***1.10***	***1.45***	1.41
5 - Central Mountain	0.67	1.47	0.74	0.97	0.96
6 - Southwestern Mountain	0.52	1.17	0.69	0.76	0.78
Virginia	0.76	1.46	0.83	1.12	1.04

Appendix C. Seasonal precipitation anomalies. Bold italics indicate significant long-term trends (1895-2016) as assessed by ordinary least squares analysis.

Seasonal Precipitation (in) Anomaly (1986-2016 relative to 1895-2000)					
VA Climate Division	Autumn (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Annual
1 - Tidewater	***0.59***	-0.02	0.09	-0.01	0.16
2 - Eastern Piedmont	***0.48***	0.00	0.14	-0.15	0.11
3 - Western Piedmont	***0.46***	-0.01	0.19	-0.16	0.12
4 - Northern	***0.49***	0.05	0.24	-0.09	0.17
5 - Central Mountain	***0.31***	0.09	0.32	-0.07	0.16
6 - Southwestern Mountain	0.21	0.05	0.07	-0.03	0.07
Virginia	0.42	0.03	0.18	-0.09	0.13

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Precipitation Trends across the Commonwealth of Virginia (1947 – 2016)

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ABSTRACT

Water is an important resource for the Commonwealth of Virginia. Too much water increases runoff, disrupt transportation networks, and contributes to school closures. Too little water may adversely impact agricultural operations. To improve climate-related information to Virginia citizens, this study assesses means and changes in precipitation across the Commonwealth of Virginia (1947 – 2016). Using daily station-level precipitation data from the Global Historical Climate Network (GHCN), descriptive statistics were calculated for 43 locations in terms of total precipitation (inches decade^{-1}), precipitation days (x>0"), and heavy precipitation days (x>1.0"). On average, locations showed an overall increase in total precipitation across the time period. The frequency of heavy rainfall events has also increased across many of the analyzed locations. Precipitation has important ramifications for agriculture, storm water management, and hazard response, and improved coordination of atmospheric-related information may be beneficial to various stakeholders across the Commonwealth.

INTRODUCTION

Heavy rainfall can lead to numerous hazards including flooding, landslides, and loss of life. From 1980 – 2013, 19 flood-related, billion-dollar disasters occurred in the United States (Smith and Matthews 2015). Combined, these events averaged a price tag of $4.5 billion. Hurricane Agnes, Fran, and Irene coupled with non-tropical events such as rapid snowmelt and ravine flooding highlight the concern in the Commonwealth of Virginia. Of the 64 federal disaster declarations issued by FEMA for the Commonwealth, 27 highlighted flooding. Others explicitly reference tropical systems or hurricanes (FEMA 2018).

While tropical systems often impact the coastal plain, precipitation associated with hurricanes often leads to inland flooding (Rappaport 2000). Mesoscale features recently flooded parts of Cape Charles, and heavy rain associated with Tropical Storm

Michael flooded parts of southwest Virginia. Flooding and heavy precipitation events (HPE) are recognized as a major hazard across the Commonwealth.

While state legislature refers to some events as so-called *nuisance* or *sunny day flooding*, flooding disrupts transportation networks, leads to cancellation of school, and plays a role in more prolonged impacts such as mold and mildew (Wong et al. 2014; Chew et al. 2006). HPE intertwine land use policy, hazard mitigation awareness, and future climate change. Recent studies have indicated shifts in the frequency and intensity of precipitation events (Lewis et al. 2018; Kunkel 2003; Wuebbles et al. 2014; Heineman 2012). In the southeast, extreme rainfall events are increasing though many stations along the Appalachian Mountains show a downward trend (USGCRP 2018). While both natural and anthropogenic forcing mechanisms are associated, it is likely that increases in atmospheric water vapor content may lead to further increases in such heavy precipitation events (Kunkel 2003).

In the United States, Peterson et al. (2013) provides a comprehensive overview of weather- and climate-related extremes. While regional assessments exist (Agel et al. 2015; Sayemuzzaman et al. 2014; Boyles and Rama 2003), the existence of climatological reviews of HPE in Virginia are unknown. The Virginia Climate Office provides some information, but the data portal is based on a climatological period that may not adequately represent the most recent changes in our Virginia climate.

This research assesses the climatological trends associated with precipitation across the Commonwealth of Virginia and draws attention to the need to better coordinate weather-related information that may be beneficial in emergency management operations, planning of our cities, or minimizing the consequences of future weather/climate-related impacts.

DATA AND METHODS

The Global Historical Climate Network (GHCN) is a database of land-based stations around the world. Subjected to detailed quality control (Menne et al. 2012), these data include a wide range of atmospheric variables such as temperature and precipitation at a variety of temporal scales (e.g. hourly; daily). Using the Climate Data Online (CDO) tool, daily precipitation values were obtained through the National Centers for Environmental Information (NCEI; 1947 – 2016). Shorter, more recent sub-periods were analyzed (1987 – 2016), but due to the heterogeneity in precipitation and limited statistical significance, these results are not shown. For this research, stations located in Virginia were selected, and only stations with at least 90% complete record were included in the analysis. In total, 43 locations met this criterion (Figure 1; Appendix A).

Using SPSS 19, descriptive statistics were generated for annual precipitation totals, precipitation days, and precipitation days exceeding 1.0" (heavy precipitation days). While other studies may use a higher threshold (Pommerenk 2016) or a cumulative value (e.g. Smirov et al. 2017), precipitation characteristics were selected based upon previous thresholds defining high precipitation days (Boyles and Raman 2003).

In addition to means, simple linear regression was used to calculate observed changes in precipitation and whether such changes were significant ($p<0.05$). The study also evaluated other thresholds (e.g. 2" days), but due to the rarity of these events and limited statistical significance, the results are not shown.

RESULTS

a. Means

Across the Commonwealth, annual precipitation averaged 43.02" year^{-1} (Figure 2; Appendix B). Only three locations average more than 50" of precipitation: Wallaceton, Meadows of Dan, and Woolwine. With only 36.2", Woodstock averaged the lowest mean annual precipitation of any station. Local topography may help explain the variability in precipitation.

From 1947 – 2016, an average of 111 precipitation days occurred at each of the locations (Figure 2; Appendix B). Burkes Garden averaged the most precipitation days (140 year^{-1}) while Clarksville the fewest (88 year^{-1}).

On average, Virginia locations experienced 10 days year^{-1} with precipitation exceeding 1.0" (Figure 2; Appendix B). Similar to annual precipitation statistics, Meadows of Dan and Woolwine observed the most 1" precipitation days, with both exceeding an average of 15 such days year^{-1}. Six locations (Blacksburg, Lafayette, Pulaski, Staffordsville, Woodstock, Wytheville) averaged less than 8, one-inch precipitation days year^{-1}.

b. Changes and Trends

Regression analysis indicates an upward trend in mean annual precipitation for 39 of the 43 locations (Figure 3; Appendix C). As a whole, precipitation increased in Virginia 0.57" decade^{-1}. Of the increases, the greatest change was found in Wallaceton (1.40 inches decade^{-1}). Several other locations observed a significant increase of more than 1.0" decade^{-1}. In total, eight significant changes were found across the Commonwealth, all indicating an upward trend.

On average, total precipitation days increased 1.69 days decade^{-1} across the commonwealth. Burkes Garden showed the largest shifts with nearly 10 more precipitation days per decade. Thirty six of the 43 stations analyzed showed an upward trend in total precipitation days. Seventeen were found to be significant ($p<0.05$).

While similar results were found for heavy precipitation days, the overall frequency of these heavy events reduced the statistical significance (Figure 2; Appendix C). All locations except two indicated a shift towards more frequent heavy precipitation days. Eight of these stations showed a significant trend. On average, heavy precipitation days increased 0.29 days decade^{-1}. With values in excess of 0.60 days decade^{-1}, Buena Vista and Hopewell showed the largest changes.

As an illustration, Figure 4 displays the annual observations and associated changes at Norfolk International Airport.

DISCUSSION AND RECOMMENDATIONS

Over the 70-year period (1947 – 2016), mean annual precipitation in Virginia seems to have increased. Additionally, both individual precipitation and heavy precipitation days, days exceeding 1.0", have also increased across much of the Commonwealth. While some precipitations variations may be associated with orographic features, the changes support other findings that show similar increase in precipitation (Smirnov et al. 2017; Pommerenk 2016; USGCRP 2018; Lewis et al. 2018). Karl et al. (2009) showed at 27% increase in heavy precipitation events in the southeast United States. In North Carolina, Boyles and Raman (2003) showed increases in precipitation during the fall and winter seasons but decreases in the summertime. The 4th National Climate Assessment (Figure 19.3) showed similar increases in precipitation across the southeast region. Over the past 25 years, days with 3 inches or more of precipitation has been historically high though decreasing trends did exist along the Appalachian Mountains (USGCRP 2018). While these studies utilize different time periods and geographic domains, the general increases in frequency and intensity in rainfall is consistent with the presented findings for Virginia. Using NOAA climate divisions, Hoffman et al. (2019) recently showed spatial variability in terms of precipitation across the Commonwealth. Future studies may explore the seasonal variability in station-level precipitation changes to uncover how precipitation is changing over the course of the calendar year.

Future projections indicate continued increases to the frequency and magnitude of heavy precipitation in the eastern United States (USGCRP 2018; IPCC 2014; Castellano and DeGaetano 2017; Kunkel et al. 2013; Wuebbles et al. 2014). Warmer air contains more water vapor, and research has shown the amount of water vapor has increased over both land and the ocean (Santer et al. 2007; Dai 2006). With changing precipitation intensity and frequency, *rain bombs* play an important role in groundwater recharge and agricultural runoff (e.g., Mohan et al. 2018), transportation systems (Suarez et al. 2005), and longer-term implications such as vector habitat or respiratory issues (Rochlin et al. 2013; Chew et al. 2006; IMO 2011). Such heavy rain events are important in the design of urban stormwater systems and mitigation of flood risk. Understanding the interconnectivity in precipitation changes, these events are also relevant in the context of a warmer world, rising sea level, and future hazard planning.

As with any study, limitations exist. While studies have used station-level data, other approaches such as fine-scale climate models (D'Onofrio et al. 2014; Maurer et al. 2007) may better represent larger geographical areas. Hydrologic watershed modeling may also help identify at-risk assets based on future precipitation scenarios (Balstrøm 2018; Larsen et al. 2010 Pedtrozo-Acuna et al. 2017). The physical mechanisms governing precipitation trends are not explicitly examined. Other studies have shown relationship between ocean circulation and atmospheric characteristics (Hoerling et al. 2016; Maleski and Martinez 2018). Variability in precipitation may be associated with larger scale phenomenon such as ENSO (el-Askary et al. 2004) and synoptic climatological approaches may be a useful approach to investigating spatial patterns in Virginia (Hewitson and Crane 2002; Dixon et al. 2016). Bindoff et al. (2013) showed *medium confidence* that anthropogenic forcing has contributed to heavy precipitation

intensification. Other studies showed similar results in terms of anthropogenic climate change attribution (Easterling et al. 2016; Janssen et al. 2014; Balan Sarojini et al. 2012). Land-use modifications (Shepherd 2005; Mahmood et al. 2010) are also areas of potential future research.

Recent events associated with Hurricane Matthew and Florence draw attention to the need for robust data and state-level support for the Virginia Climate Office. A recent report suggested agricultural damage associated with Hurricane Michael topped $1.3 billion (Daniels 2018). In Central Virginia, prolonged rainfall disrupted transportation networks (Fox 2018). Changes in the intensity, duration, or seasonal timing of heavy precipitation events presents a wide range of challenges. These multi-sector challenges crisscross Virginia and require collaboration across disciplines, and decision-makers must rely upon updated, real-time information and the full body of peer-reviewed evidence. As local climate change impacts become more apparent, additional data and tools such as Geographic Information Systems, downscaled climate models, and advanced remote sensing tools should be leveraged to provide up-to-date information to stakeholders through the Virginia Climate Office.

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Figure 1. Virginia observation locations (Appendix A).

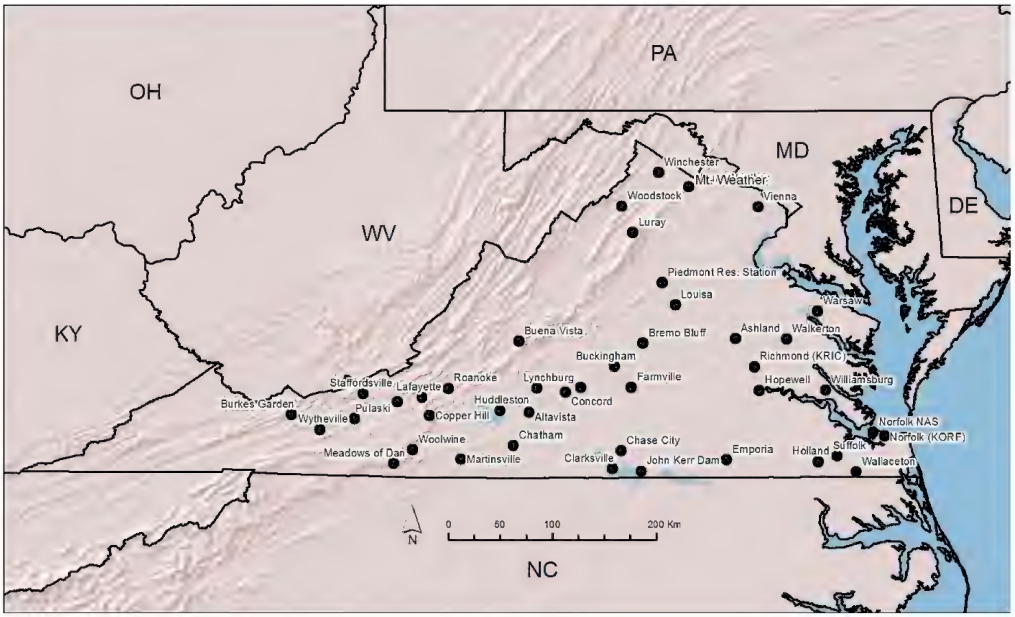


Figure 2. (top to bottom) Mean total Precipitation (inches), precipitation days, and heavy precipitation days (See Appendix B).

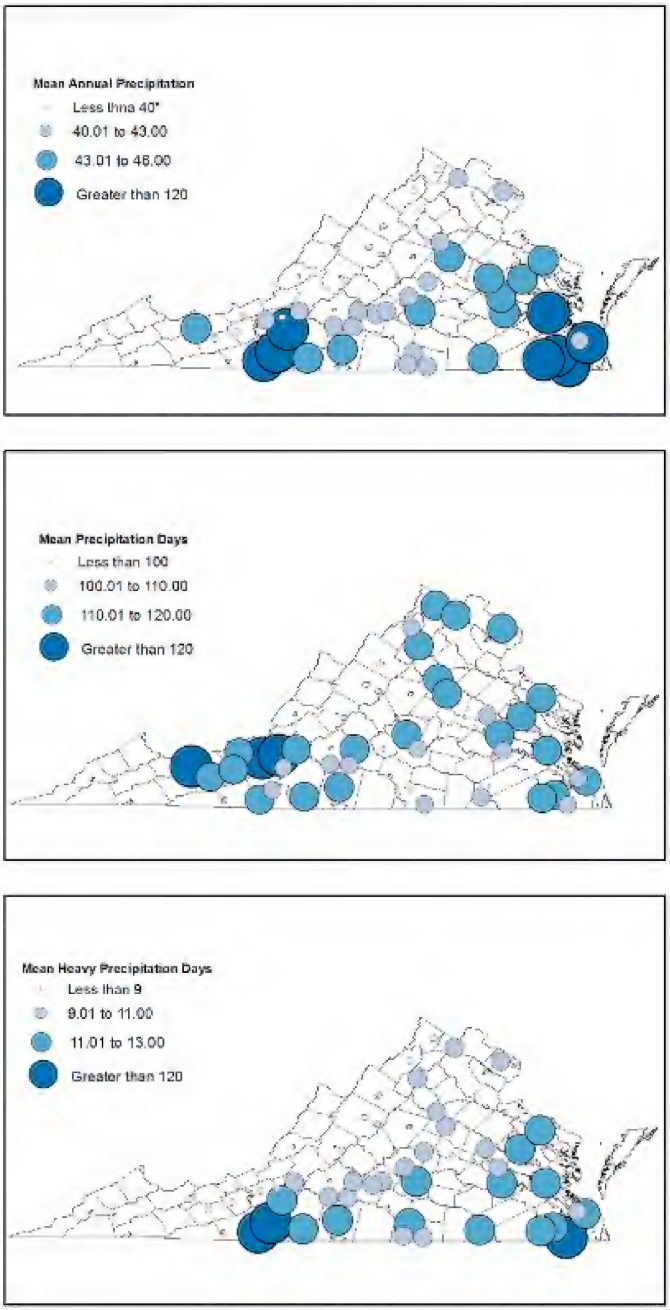


Figure 3. (top to bottom) Changes (decade^{-1}) in total precipitation (inches), precipitation days, and heavy precipitation days (Appendix C).

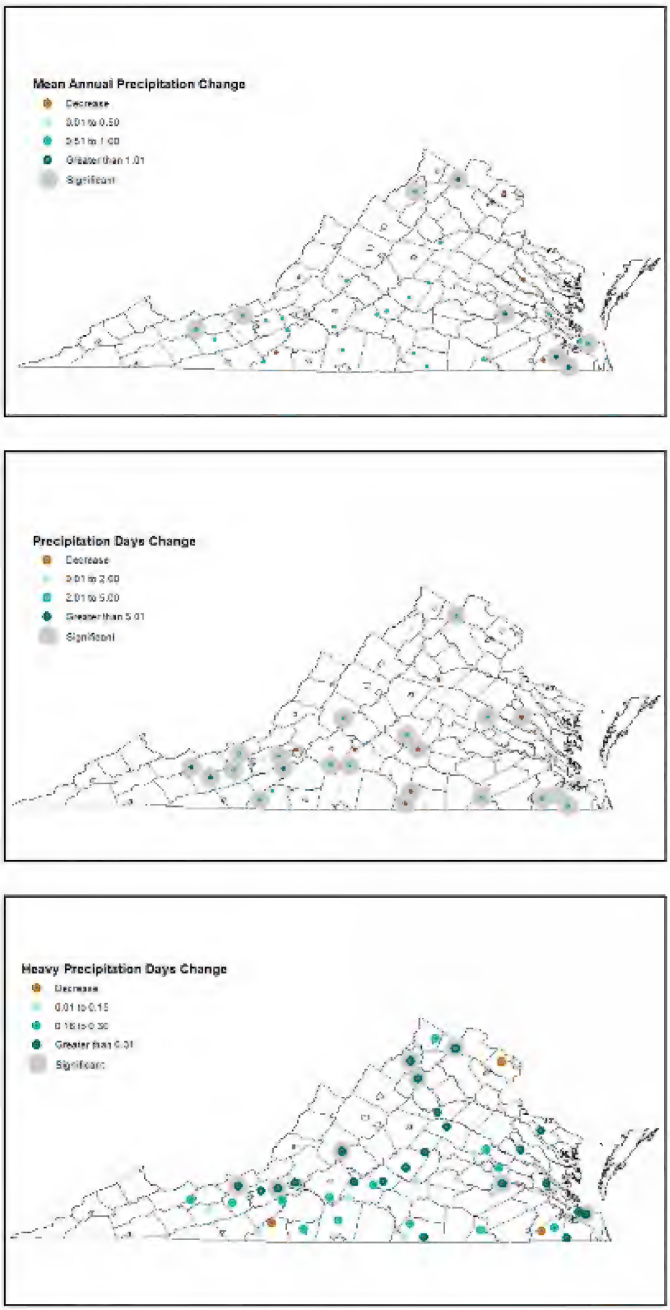
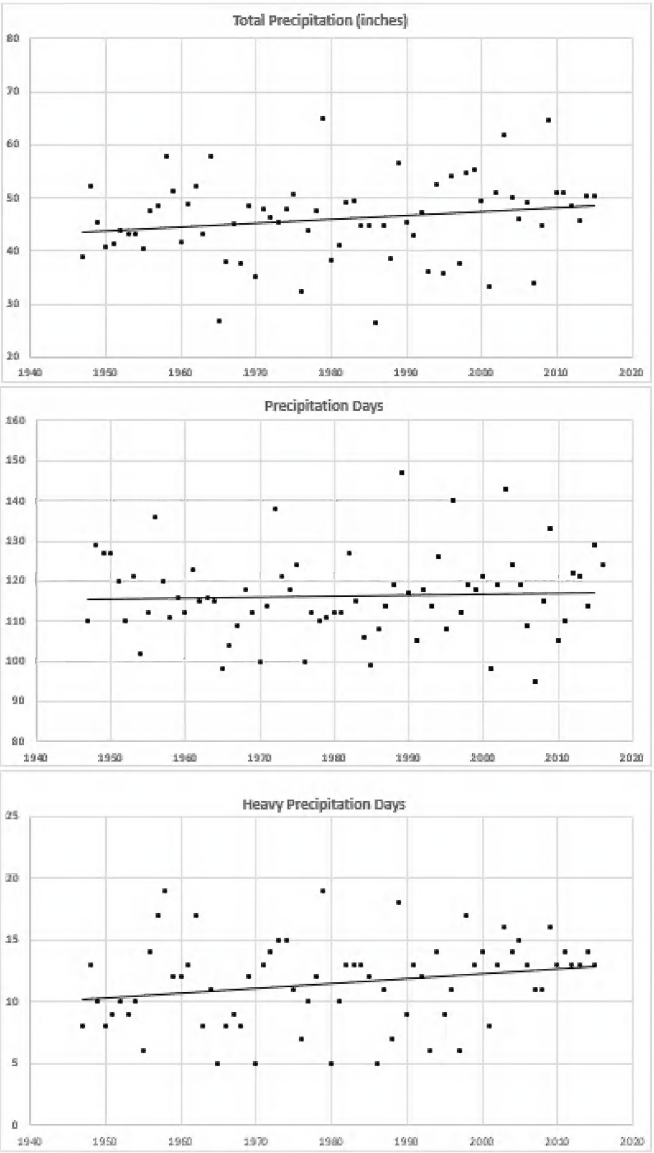


Figure 4. Annual total precipitation, precipitation days, and heavy precipitation days at Norfolk International Airport. Trend line associated with the observations.



Appendix A. Virginia observation locations

Station	Latitude	Longitude	GHCND ID	Elevation (m)
Altavista	37.1	-79.3	USC00440166	161.2
Appomattox	37.3	-78.8	USC00440243	259.1
Ashland	37.8	-77.5	USC00440327	67.1
Blacksburg	37.2	-80.4	USC00440766	641
Bremo Bluff	37.7	-78.3	USC00440993	68.6
Buckingham	37.5	-78.5	USC00441136	176.8
Buena Vista	37.7	-79.4	USC00441159	256
Burkes Garden	37.1	-81.3	USC00441209	935.1
Chase City	36.8	-78.5	USC00441606	155.4
Chatham	36.8	-79.4	USC00441614	198.4
Clarksville	36.6	-78.6	USC00441746	100.6
Concord	37.3	-79.0	USC00441955	248.4
Copper Hill	37.1	-80.1	USC00441999	870.8
Emporia	36.7	-77.6	USC00442790	30.5
Farmville	37.3	-78.4	USC00442941	137.2
Holland	36.7	-76.8	USC00444044	24.4
Hopewell	37.3	-77.3	USC00444101	12.2
Huddleston	37.1	-79.5	USC00444148	273.4
John Kerr Dam	36.6	-78.3	USC00444414	76.2
Lafayette	37.2	-80.2	USC00444676	402.3
Louisa	38.0	-78.0	USC00445050	128
Luray	38.7	-78.4	USC00445096	426.7
Lynchburg	37.3	-79.2	USW00013733	286.5
Martinsville	36.7	-79.9	USC00445300	231.6
Meadows of Dan	36.7	-80.4	USC00445453	678.2
Mount Weather	39.1	-77.9	USC00445851	505.7
Norfolk (KORF)	36.9	-76.2	USW00013737	9.1
Norfolk NAS	36.9	-76.3	USW00013750	5.2
Piedmont Research Station	38.2	-78.1	USC00446712	158.5
Pulaski	37.1	-80.8	USC00446955	563.9
Richmond (KRIC)	37.5	-77.3	USW00013740	50
Roanoke	37.3	-80.0	USW00013741	358.1
Staffordsville	37.3	-80.7	USC00448022	594.4
Suffolk	36.7	-76.6	USC00448192	6.7
Vienna	38.9	-77.3	USC00448737	127.4
Walkerton	37.7	-77.0	USC00448829	15.2
Wallaceton	36.6	-76.4	USC00448837	6.1
Warsaw	38.0	-76.8	USC00448894	42.7
Williamsburg	37.3	-76.7	USC00449151	21.3
Winchester	39.2	-78.1	USC00449186	207.3
Woodstock	38.9	-78.5	USC00449263	205.7
Woolwine	36.8	-80.3	USC00449272	457.2
Wytheville	37.0	-81.1	USC00449301	749.2

Appendix B. Annual mean precipitation, precipitation days, and heavy precipitation (1.0"+) days (1947 – 2016).

Station	Total Precipitation (inches year^{-1})	Precipitation Days (days year^{-1})	Heavy Precipitation Days (days year^{-1})
ALTAVISTA	40.9	101.7	10.6
APPOMATTOX	41.9	99.3	10.7
ASHLAND	43.0	101.2	10.9
BLACKSBURG NWS	40.7	129.5	7.7
BREMO BLUFF	40.2	98.1	10.1
BUCKINGHAM	42.6	111.3	10.7
BUENA VISTA	38.7	99.2	8.6
BURKES GARDEN	44.9	140.6	8.5
CHASE CITY	42.5	92.3	11.2
CHATHAM	44.2	116.6	11.1
CLARKSVILLE	40.8	88.8	10.1
CONCORD	42.4	99.3	10.6
COPPER HILL	46.5	107.1	11.6
EMPORIA	43.6	104.7	11.2
FARMVILLE	43.2	101.2	11.0
HOLLAND	48.3	114.3	12.3
HOPEWELL	44.9	109.3	11.5
HUDDLESTON	41.3	108.8	10.1
JOHN KERR DAM	42.0	108.9	11.0
LAFAYETTE	38.9	123.1	7.8
LOUISA	43.1	112.1	10.8
LURAY	39.8	114.9	9.4
LYNCHBURG	41.0	118.1	9.3
MARTINSVILLE	44.4	112.7	11.2
MEADOWS OF DAN	55.8	118.9	15.9
MOUNT WEATHER	41.5	111.7	10.0
NORFOLK (KORF)	46.3	116.4	11.5
NORFOLK NAS	41.1	109.8	9.4
PIEDMONT RES. STATION	41.5	114.7	10.5
PULASKI	37.1	113.1	7.9
RICHMOND (KRIC)	44.0	114.2	11.0
ROANOKE	41.1	119.0	9.6
STAFFORDSVILLE	38.6	116.6	7.9
SUFFOLK	48.6	116.6	12.8
VIENNA	42.9	117.5	10.2
WALKERTON	43.8	115.1	11.4
WALLACETON	50.4	100.5	13.4
WARSAW	43.2	110.4	11.1
WILLIAMSBURG	48.3	118.8	12.5
WINCHESTER	38.2	114.6	8.6
WOODSTOCK	36.3	106.6	7.0
WOOLWINE	53.4	107.6	15.5
WYTHEVILLE	38.2	119.0	7.6

Appendix C. Decade^{-1} changes in total precipitation, precipitation days, and heavy precipitation days (1947 – 2016). Significant values are bold and underlined ($p<0.05$).

Station	Total Precipitation (inches decade-1)	Precipitation Days (days decade-1)	Heavy Precipitation Days (days decade-1)
ALTAVISTA	0.40	**4.56**	0.10
APPOMATTOX	0.74	1.79	0.36
ASHLAND	0.47	**3.56**	0.24
BLACKSBURG NWS	0.71	1.86	0.57
BREMO BLUFF	0.53	1.05	0.37
BUCKINGHAM	0.87	**3.11**	0.40
BUENA VISTA	0.84	**2.76**	**0.69**
BURKES GARDEN	**0.94**	**9.67**	0.18
CHASE CITY	0.70	**-3.09**	0.28
CHATHAM	0.76	0.35	0.17
CLARKSVILLE	0.41	**-3.90**	0.07
CONCORD	1.00	1.33	0.24
COPPER HILL	0.73	**8.94**	0.20
EMPORIA	0.76	**2.69**	0.15
FARMVILLE	0.05	**-1.69**	0.14
HOLLAND	-0.22	**2.61**	0.00
HOPEWELL	**1.28**	1.70	**0.66**
HUDDLESTON	0.60	**3.05**	0.24
JOHN KERR DAM	0.53	1.49	0.31
LAFAYETTE	0.69	**2.59**	**0.45**
LOUISA	0.22	0.80	0.32
LURAY	0.25	0.14	**0.42**
LYNCHBURG	0.30	-0.70	0.37
MARTINSVILLE	0.13	0.41	0.21
MEADOWS OF DAN	0.72	**3.16**	0.13
MOUNT WEATHER	**1.25**	**3.96**	**0.59**
NORFOLK (KORF)	**0.95**	0.31	**0.45**
NORFOLK NAS	0.81	0.54	0.33
PIEDMONT RES. STATION	0.59	-1.23	0.30
PULASKI	0.34	**2.41**	0.30
RICHMOND (KRIC)	0.26	0.49	0.19
ROANOKE	0.48	-0.82	0.37
STAFFORDSVILLE	**0.87**	**4.59**	**0.51**
SUFFOLK	**1.20**	**1.53**	0.19
VIENNA	-0.54	1.39	-0.20
WALKERTON	-0.19	**-2.47**	0.35
WALLACETON	**1.40**	**3.72**	0.52
WARSAW	0.41	0.53	0.40
WILLIAMSBURG	1.00	1.30	0.30
WINCHESTER	0.23	0.64	0.15
WOODSTOCK	**0.86**	0.04	**0.32**
WOOLWINE	-0.26	2.09	-0.08
WYTHEVILLE	0.58	**5.23**	0.10